POWER PLANT ENGINEERING

Established Over 29 Years

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Contents of this Issue

Page

Features of the Middletown Power Station. Illustrated....724

Conditions Affecting the Use of Preheated Air. Illustrated..734

Progress in Mechanical Stoker Practice. Illustrated.....736

Methods of Obtaining a Heat Balance—II. Illustrated.....737

Packing Glands for Steam Turbines. By J. Y. Dahlstrand. Illustrated 740

Recent European Hydraulic Machinery Design. By F. Johnstone-Taylor. Illustrated 742

Fuel Pumps for Solid Injection Engines. By H. F. Birnie. Illustrated 745

Rotted Piles Necessitate Rebuilding of Plant Foundation. Illustrated 749

Electrical Features of the Somerset Station. Illustrated....750

Fittings and Connectors for Outdoor Substations. By Wm. T. O'Connell. Illustrated.....754

Prevention of Explosions in Air Receivers. By William F. Parish and William B. Smith Whaley.....755

Test Methods for Enameled Electric Wire. Illustrated.....756

Harbor Point Station Will Operate First Unit in 1926. Illustrated 757

Steel Stack Reinforced While in Service. Illustrated.....758

Letters Direct from the Plant: Overcoming Vibrations Caused by Steam Engines. Corrosion by Oxygen Proved by Practice. Steam Gage Piping Important. Illustrated.....759

Questions and Answers: Is Concrete Suitable for Boiler Settings? Why It Is Cheaper to Generate Steam at High Pressure. What the Cards Show. Regulating Ring Determines Amount of Blowback. When D. C. Produces A. C. How to Synchronize the Generators. Illustrated.....761

Editorial Comment: When Facts Are Presented. You Can't Catch an Economic Force with a Policeman.....764

Off Duty 765

It Was Light at the Golden Gate. Illustrated.....766

New Water Gage Safety Valves Open Automatically. Illustrated 774

New Relay for Use On Distribution Lines. Illustrated.....775

News Notes 775

Books and Catalogs.....776

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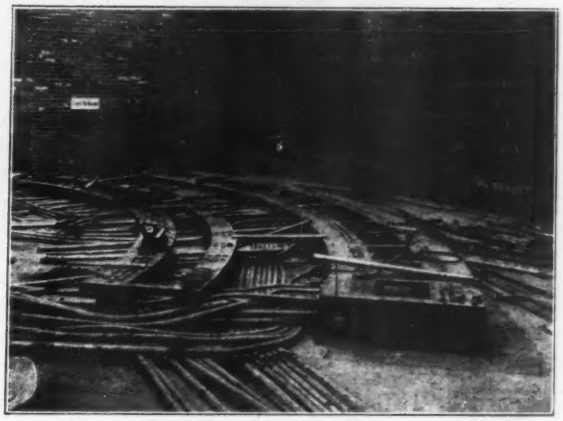
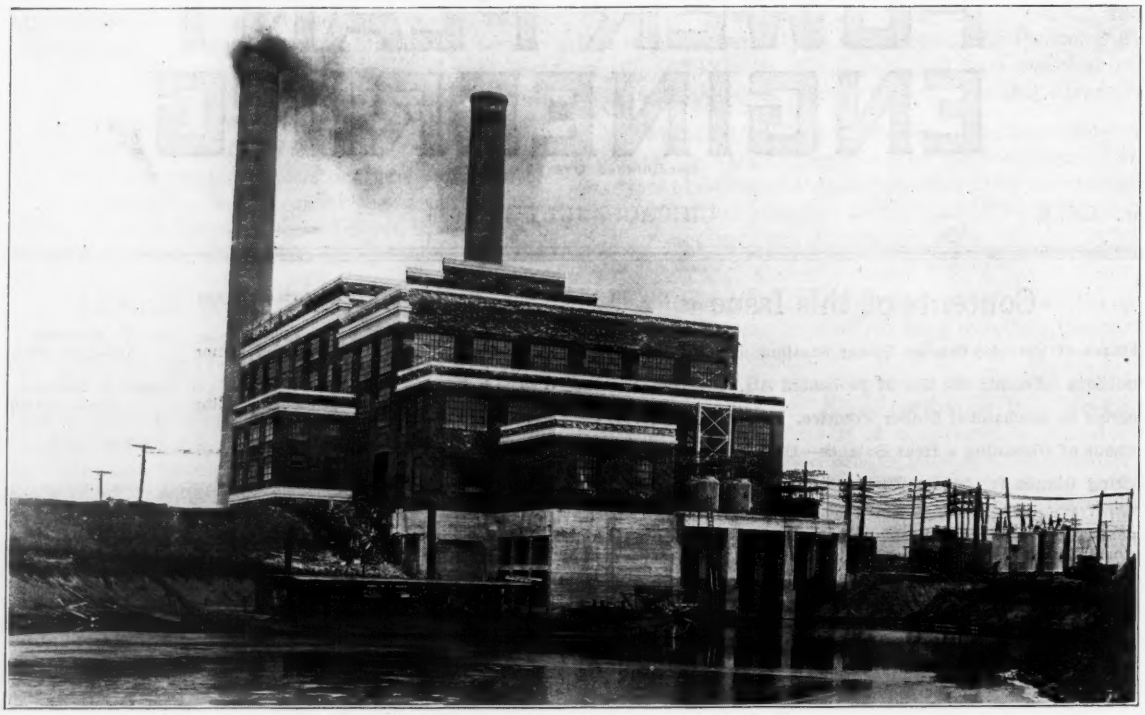


The Medulla Oblongata

AT THE BASE of the brain just below the cerebrum there is situated a small mass of nervous matter known as the Medulla Oblongata. It is pyramidal in form, about 1¼ in. long, 1 in. broad at the base, and is composed of millions of living threads of microscopic tenuity, each extending from a sensory nerve cell or a motor nerve cell to that central nervous mass, which, in vertebrates, we call the brain. Each of these tiny threads is the fixed path for certain nervous impulses traveling between the brain and remote parts of the body.

In the above photograph is shown what we are pleased to term the medulla oblongata of an electric generating station, for it shows that concentrated maze of conduit which connects the main control board (the brain of the station) with the various circuits leading to all the various electrical equipment in the plant. This, naturally, is an important part of every electric station but it is not often that the nerves are laid bare as in this picture. More specifically, the picture shows the sills for the main switchboard in the Somerset Station, the electrical features of which are described in this issue.

HOT AIR is objectionable to us at certain seasons of the year, but pleasing at other times. At all seasons, however, it is a valuable substance for maintaining combustion in a properly designed furnace, in which case we call it preheated air. On page 734 you will find a discussion of methods of computing the amount of preheated air to give good combustion under various fuel and furnace conditions.



Features of the Middletown Power Station

PENNSYLVANIA-NEW JERSEY POWER SYSTEM STRENGTHENED BY NEW PLANT ON SUSQUEHANNA. PULVERIZED ANTHRACITE FUEL AND BLEED FEED WATER HEATING ARE FEATURES

SERVING A STRIP of territory extending from Hanover, Pa., on the west to Dover, N. J., on the east is a system of interconnected power plants which are operated by the W. S. Barstow Management Ass'n. Included among the cities served are Hanover, York, York Haven, Middletown, Harrisburg, Lebanon, Reading and Easton, Pa., Susee, Hackettstown, Dover, Washington, Lebsnod and Lambertville, N. J. With the industrial development of this territory, which has been rapid during the past few years, has come an ever increasing demand for power. It was to meet this demand and to strengthen the company's system at its western end that the Metropolitan Edison Co., one of the Barstow interests, planned and built the Middletown station on the Susquehanna River a few miles southeast of Harrisburg.

Many perplexing engineering problems were presented in the design of this plant and the manner in which they have been solved has resulted in an economical and reliable power plant. In many respects the first unit of this plant is serving as a research laboratory to guide the engineering department in its selection of equipment, as the plant is enlarged, and in the design of other plants to be built by the company. The ultimate capacity of the plant as designed will be 200,000 kw., only one generating unit of 30,000 kw. capacity being installed at the present time, this having been started last December.

Coal used during this month was taken from seven mines and some anthracite from the river bed. During the month the plant was operated from Monday morning until Saturday noon and consequently had the losses incurred in bringing the cold plant in service Monday morning.

The following operating data are for the month of March, which was the second month of 24-hr. operation of the plant:

Total kw-hr. generated	11,214,000
Kw-hr. used by station	762,140
Net output	10,551,860
Total coal burned, lb	12,892,845
Total B. t. u. in coal (as received) in millions	173,657
B. t. u. per kw-hr. net output	16,615
Lb. coal per kw-hr. net	1.233

Coal Analysis	Low	High
B. t. u.	11,987	14,013
Ash, per cent	9.32	16.07
Sulphur, per cent	0.72	5.0
Fixed carbon, per cent	56.0	78.0
Volatile, per cent	7.86	31.7

RIVER BED FURNISHES COAL

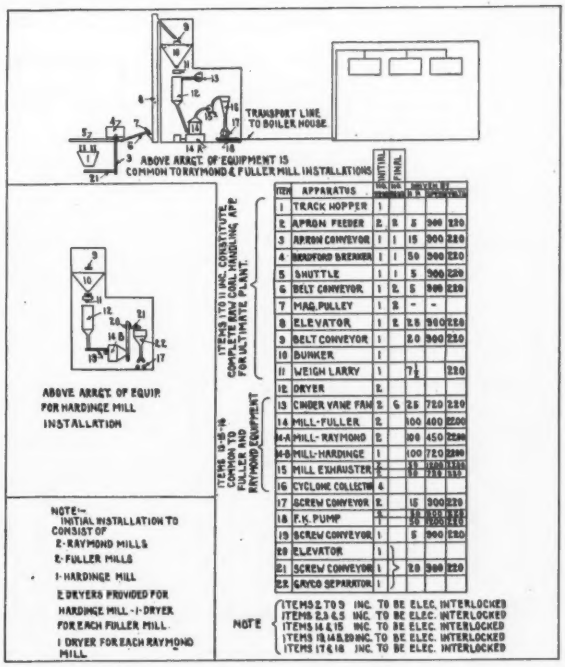
By locating the plant on the Susquehanna River there is at hand an almost unlimited supply of condensing water and there is the additional advantage that this river carries along its bed a supply of anthracite known as river coal which has been washed into the river from the dumps in the anthracite mining regions. Plans have been made to dredge this coal from the river, mix it with bituminous coal and burn it in pulverized fuel furnaces. Surrounding the plant buildings is a large tract of land owned by the company and used as storage space for coal which is stored and reclaimed by means of a drag scraper. Cars loaded with coal are switched over a double track hopper from which the coal is delivered through a system of conveyors and elevators, as shown in diagram in Fig. 1, to

the bunker in the pulverizing house. In case the coal is not needed for immediate use, it is delivered from the apron conveyor to a shuttle instead of to the Bradford breaker and conveyed to the storage pile, thus releasing the cars and saving demurrage charges.

Preparation of Pulverized Coal

Distribution of the coal in the bunker of the pulverizing house is accomplished by means of a belt conveyor fitted with a plow distributor. This bunker is divided into four compartments for convenience in mixing river coal with bituminous. The weigh larry which travels beneath the bunker and serves the pulverizing mills is also divided into two compartments to facilitate mixing. By means of this larry and instruments to measure the power required to drive the different mills the company will secure an accurate comparison of the cost of preparing coal by each mill in the plant. Five pulverizing mills are installed, two Fuller, two Raymond and one Hardinge.

At present four dryers are installed, these are two Wood dryers and two Fuller-Randolph dryers. The two Wood dryers deliver to the Hardinge mill and one Randolph dryer delivers to a Raymond mill, while the other delivers to a Fuller mill. Plans call, however, for the installation of two more Randolph dryers to serve the other two mills. The Wood dryers use the stack gases and exhaust steam for heating the coal to drive off the moisture. A steel plate fan draws the gases from the stack breeching through the coal in the dryer and discharges it to atmosphere through a cyclone collector that prevents the waste of coal dust. To prevent the danger of overheating the coal, indicating and recording thermometers are used to show the temperatures of the gas to and the coal from the dryers. The Randolph dryers are heated by exhaust steam from the main plant. They also use flue gas for carrying off the moisture. The pulverized coal is transmitted to the boiler room bins through piping by means of two Fuller-Kenyon pumps. When the boiler room bins are full, indicating lamps in the pulverizing house light up, giving warning to the attendants. When a bin is full the coal is automatically diverted to the next bin. Another feature of the coal handling equipment which is of interest is the electrical interlocking system employed on the elevating and conveying machines by means of which the entire system from the track hoppers to the bunker in the pulverizing house starts and stops in proper sequence, no matter from which control point the equipment may be operated. So completely automatic is the machinery in the pulverizing house that


TRANSPORT LINE TO BOILER HOUSE
3 ABOVE ARRGT. OF EQUIPMENT IS COMMON TO RAYMOND & FULLER MILL INSTALLATIONS
ABOVE ARRGT. OF EQUIP. FOR HARDINGE MILL INSTALLATION
ITEMS 1 TO 11 INC. CONSTITUTE COMPLETE RAW COAL HANDLING APP. FOR ULTIMATE PLANT.
ITEMS 13-15-16 COMMON TO FULLER AND RAYMOND EQUIPMENT
NOTE:- INITIAL INSTALLATION TO CONSIST OF 2-RAYMOND MILLS 2-FULLER MILLS 1-HARDINGE MILL 2 DRYERS PROVIDED FOR HARDINGE MILL - 1 DRYER FOR EACH FULLER MILL 1 DRYER FOR EACH RAYMOND MILL
NOTE
ITEMS 2 TO 9 INC. TO BE ELEC. INTERLOCKED
ITEMS 2 & 6.5 INC. TO BE ELEC. INTERLOCKED
ITEMS 14 & 15 INC. TO BE ELEC. INTERLOCKED
ITEMS 18,14 & 19 INC. TO BE ELEC. INTERLOCKED
ITEMS 17 & 18 INC. TO BE ELEC. INTERLOCKED

ITEM	APPARATUS	NO. REQ'D INITIAL	NO. REQ'D FINAL	MOTORS H.P.		R.P.M.	VOLTS
1	TRACK HOPPER	1					
2	APRON FEEDER	2	2	5		900	220
3	APRON CONVEYOR	1	1	15		900	220
4	BRADFORD BREAKER	1	1	30		900	220
5	SHUTTLE	1	1	5		900	220
6	BELT CONVEYOR	1	2	5		900	220
7	MAG. PULLEY	1	2	-		-	
8	ELEVATOR	1	2	2.5		900	220
9	BELT CONVEYOR	1		20		900	220
10	BUNKER	1					
11	WEIGH LARRY	1		7½			220
12	DRYER	2					
13	CINDER VANE FAN	2	6	25		720	220
14	MILL-FULLER	2		100		400	2200
M-A	MILL-RAYMOND	2		100		450	2200
M-B	MILL-HARDINGE	1		100		720	2200
15	MILL EXHAUSTER	2		25		1200	2200
		2		20		720	550
16	CYCLONE COLLECTR	4					
17	SCREW CONVEYOR	2		15		900	220
18	F.K. PUMP	2		30		450	220
		2		30		900	220
19	SCREW CONVEYOR	1		5		900	220
20	ELEVATOR	1					
21	SCREW CONVEYOR	1		20		900	220
22	GAYCO SEPARATOR	1					

FIG. 1. COAL IS PULVERIZED IN A BUILDING SEPARATED FROM THE POWER PLANT

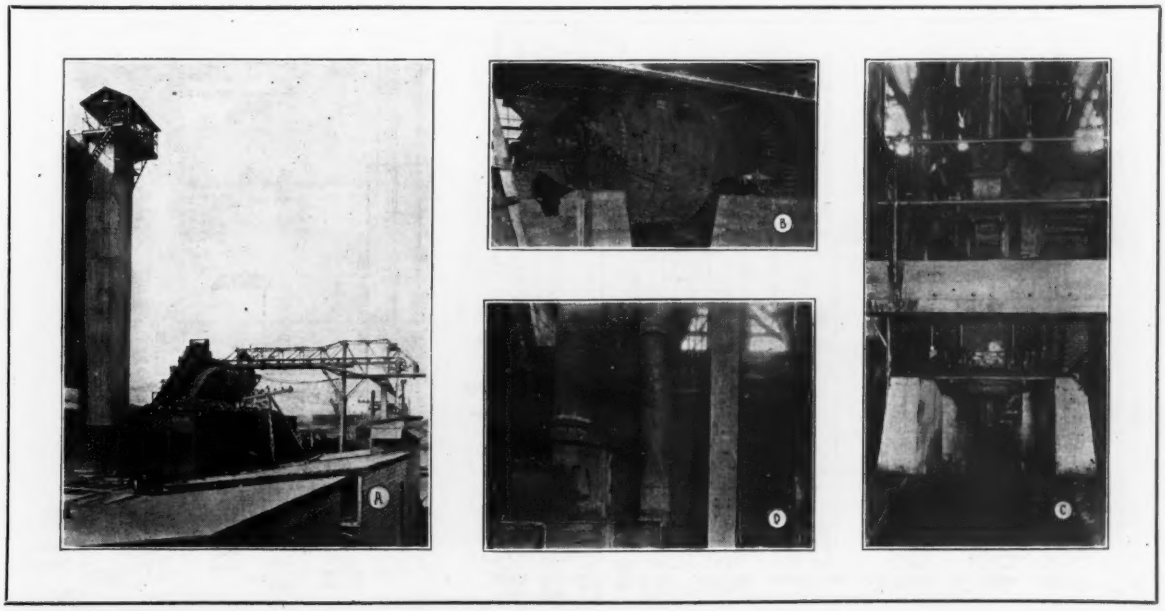


FIG. 2. COAL HANDLING AND PULVERIZING EQUIPMENT. A. PHOTO OF COAL RECEIVING EQUIPMENT TAKEN BEFORE THE HOUSE WAS BUILT OVER HOPPER. B. HARDINGE PULVERIZING MILL. C. FULLER MILLS. D. RAYMOND MILLS

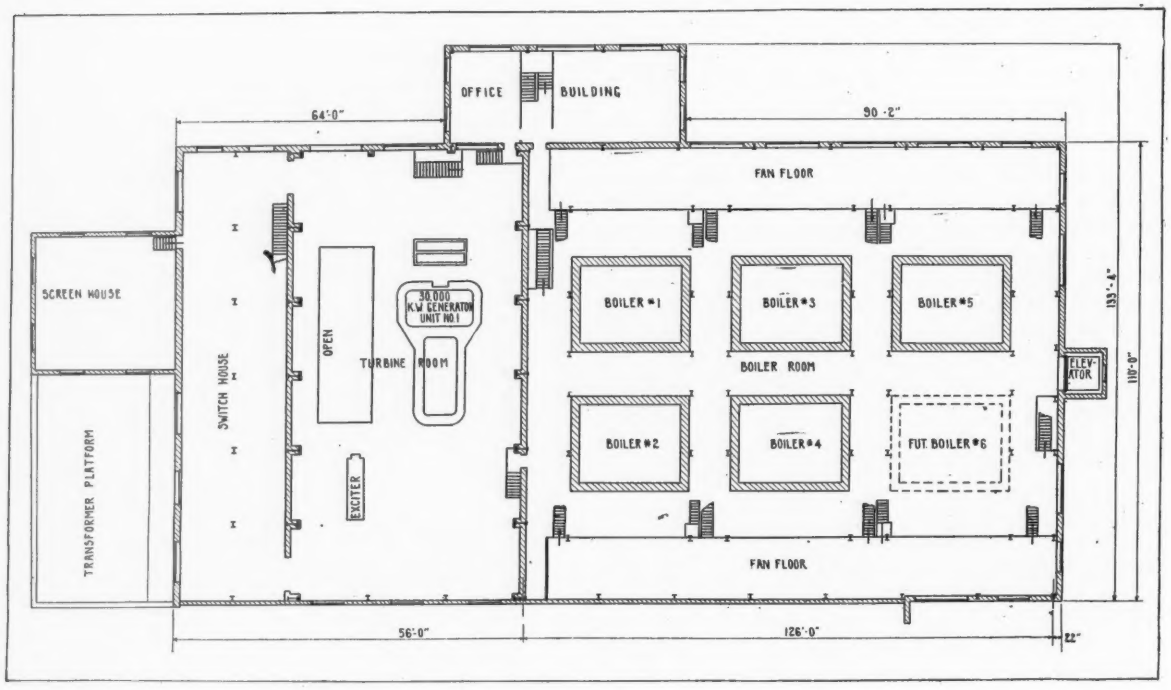


FIG. 3. PLAN SHOWING PRINCIPAL EQUIPMENT IN MIDDLETOWN PLANT

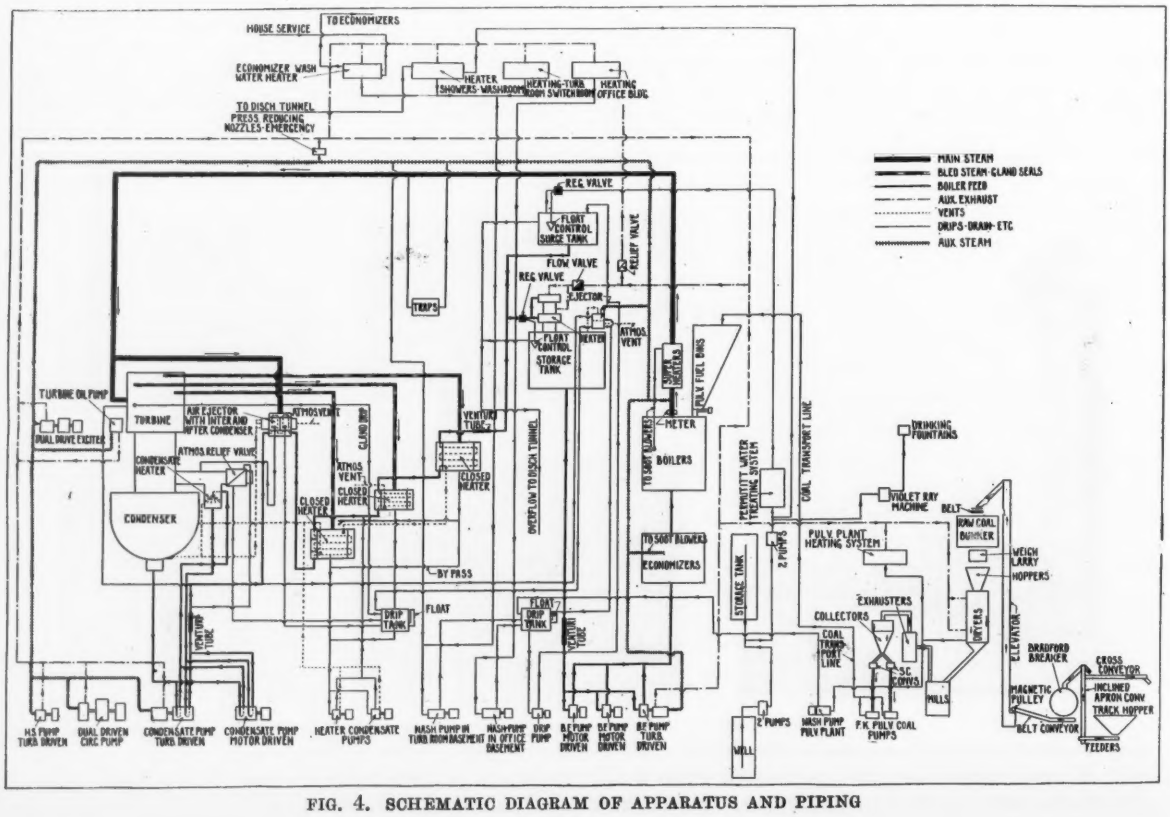


FIG. 4. SCHEMATIC DIAGRAM OF APPARATUS AND PIPING

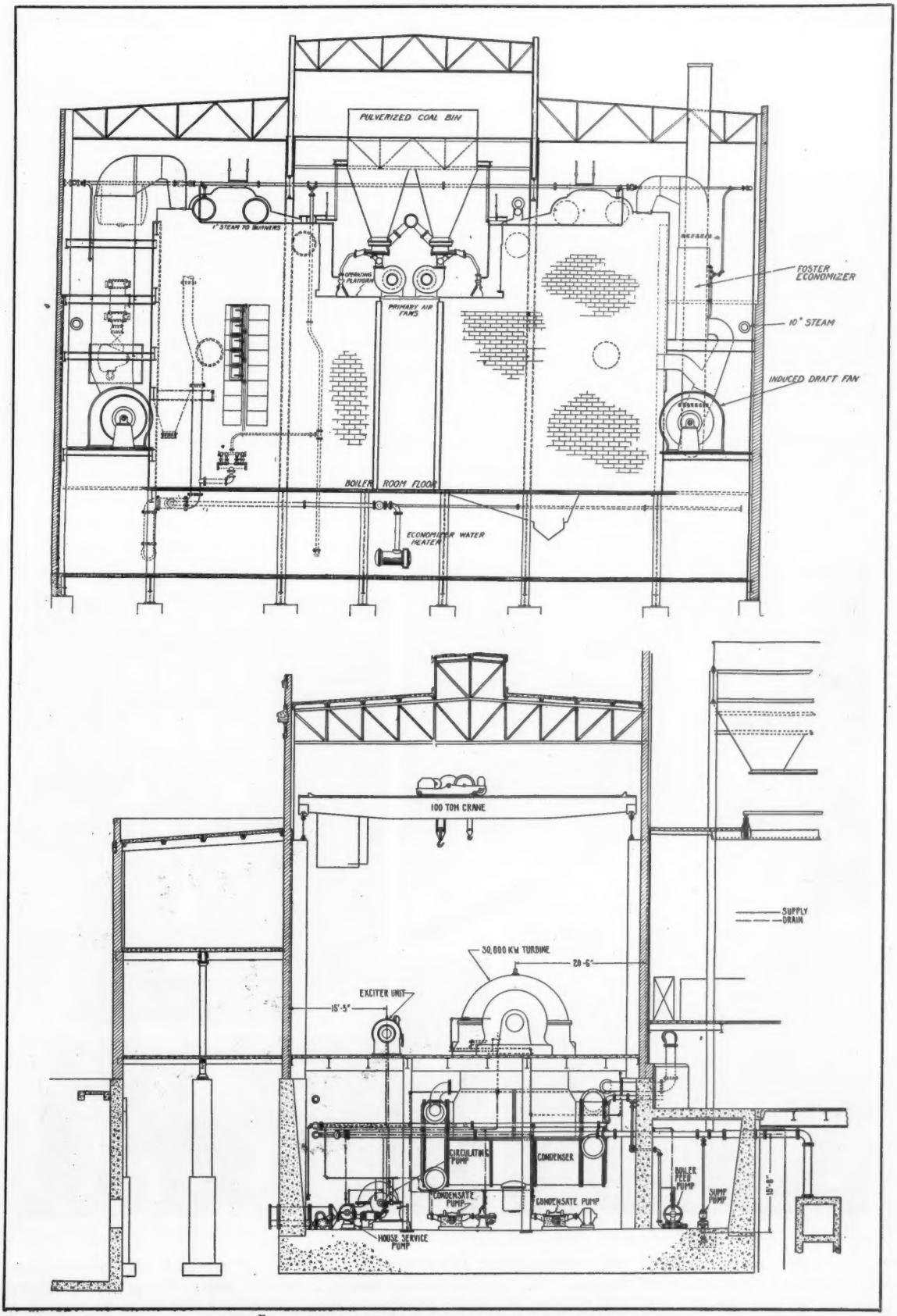


FIG. 5. SECTIONS THROUGH BOILER AND TURBINE ROOMS

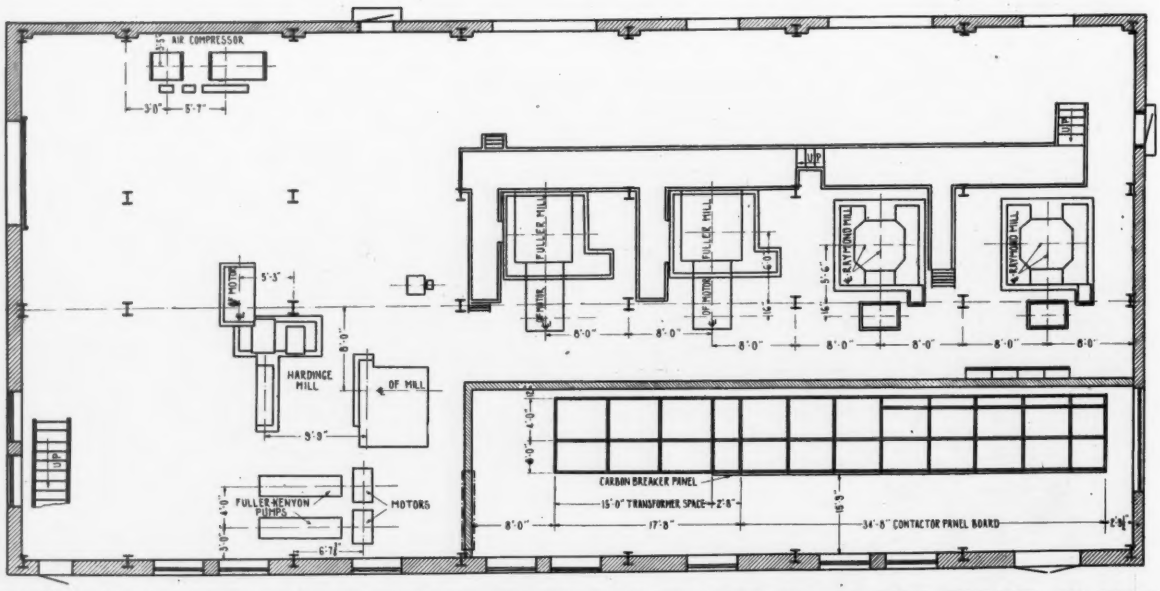


FIG. 6. PLAN OF PULVERIZING HOUSE SHOWS ELECTRICAL CONTACTOR EQUIPMENT IN ROOM ENCLOSED BY BRICK WALLS

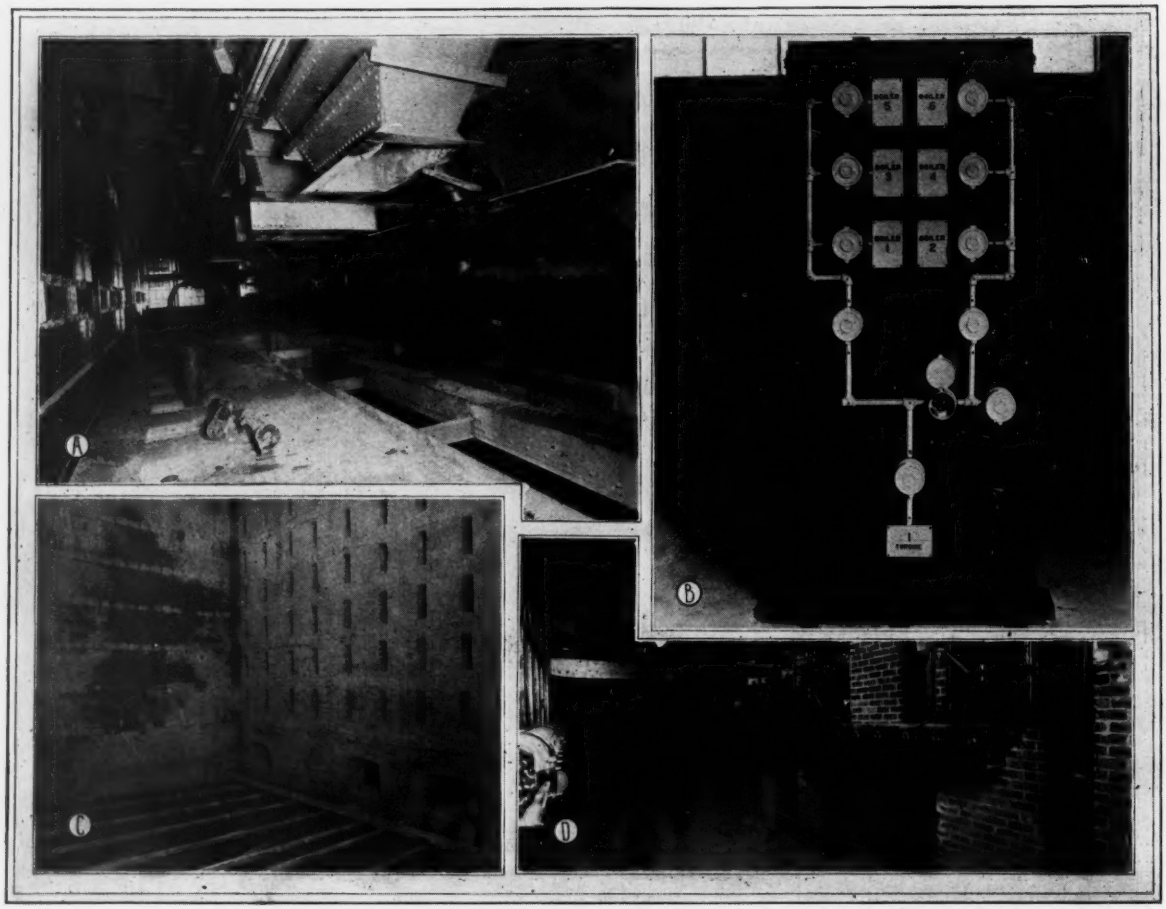


FIG. 7. THREE BOILERS OF THE SIX FOR THE UNIT ARE NOW IN OPERATION. A. GENERAL VIEW OF THE FIRING AISLE SHOWING VERTICAL TYPE BURNERS. B. CONTROL BOARD FOR THE BOILER ROOM. C. INTERIOR OF BOILER FURNACE LOOKING TOWARD SIDE AND FRONT. D. TUBES FORMING WATER SCREEN ARE ATTACHED TO HEADER OUTSIDE THE FURNACE WALL

only three men are required on a shift to operate it. All the switches controlling the motors in the pulverizing room are located in a switchroom carefully partitioned off from the other part of the building, as a precaution against an electric spark starting an explosion. The building is heated by exhaust steam from the station auxiliaries, Nash Engineering Co. pumps being employed to return the condensate.

Steam Is Generated at 350 Lb.

Each unit of the plant will have four boilers set in two rows of two, each row being served by one stack. At present only three boilers are installed. These are Connelly four-pass boilers, each rated at 1477 hp., generating steam at 350 lb. gage. The auxiliary piping carries saturated steam but the main piping to the turbine carries steam of the same pressure but superheated to a total temperature of 660 deg. F. The furnaces serving these boilers are built for a vertical flame, the volume above the water screen being 11,000 cu. ft., and the width 24 ft. 1½ in. The construction is such as to provide horizontal air ducts between the lining and the outer wall through which secondary air is passed from registers at the rear and sides to ports in the front lining of the furnace. The water screen is in the direct circulation of the boiler. American arches are used in all the furnaces, but the company is testing out several different makes of fire brick and cements.

In the first unit of the plant two makes of economizers are used, Foster economizers being used in one row of boilers and Sturtevant in the other, and careful accounts are being kept to determine which gives the better service record. The heating surface in the economizer is equal to 50 per cent of that in the boiler which it serves. Two induced draft fans for each boiler draw the gases through the economizers and deliver them to the breeching which is of the accordion type, manufactured by Connery & Co.

Pulverized Coal Burners

From the coal bins, of which there is one for each boiler, two groups of three feeders each, driven by two 12-hp. brush shifting variable speed motors deliver the coal to the six burners which are provided for each boiler. This equipment which was furnished by the Combustion Engineering Corp., is designed for 35 per cent primary air, the 65 per cent secondary air enters at the front of the furnace as previously described. The primary air, that which enters with the coal in the burner, is supplied by motor driven fans, one being provided for each two

FIG. 8. MOTOR DRIVEN BOILER FEED PUMPS

FIG. 9. TWIN STRAINERS REMOVE SOLID PARTICLES FROM HOUSE SERVICE WATER

FIG. 10. ZEOLITE SOFTENERS TREAT MAKE-UP WATER

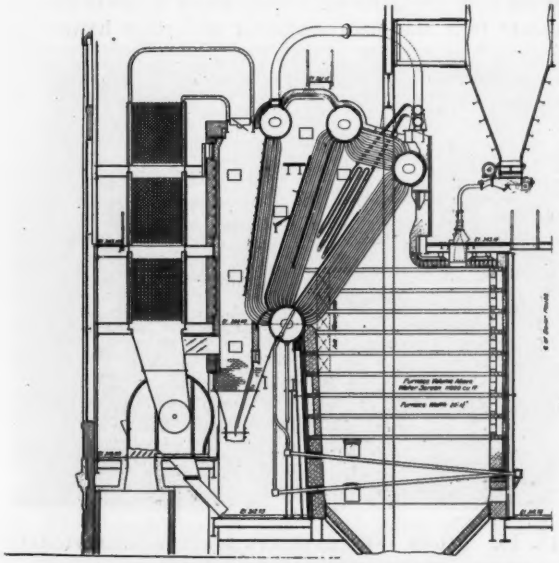


FIG. 11. SECTION THROUGH BOILER AND SETTING

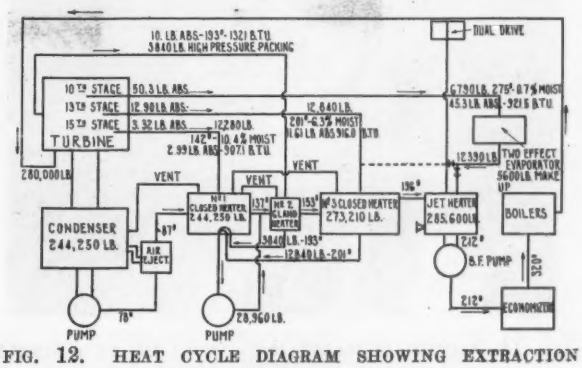


FIG. 12. HEAT CYCLE DIAGRAM SHOWING EXTRACTION WITH LOAD OF 26,720 KW.

FIG. 13. THE FIRST GENERATING UNIT OF THE PLANT HAS A CAPACITY OF 30,000 KW.

boilers, the pressure carried is 15 in. of water. The secondary air is drawn into the furnace by the draft created by the induced draft fans, which are driven by 125-hp. slip ring motors capable of running at three different speeds. This draft is measured at five different points and indicated by a Bailey multipointer draft gage on the boiler control board upon which is also mounted a Bailey boiler meter which gives the steam-flow, air-flow indications. There is also a recorder showing the temperature of the water and the flue gas entering and leaving the economizer. The boiler attendants are kept informed as to the load on the station by a Payne Dean load indicator.

Ashes which accumulate in the bottom of the furnace are discharged into a sluice which carries them into the yard where they are used for filling purposes. This sluice is built without slope but the ash is carried along with water from high pressure nozzles spaced along the length of the sluice. Cinders carried over to the third and fourth passes of the boiler also being sluiced out into the yard.

Water for service and boiler feeding comes from wells, being pumped to a supply tank whence it is delivered to pumps which force it through a Permutit water softening system to a Cochrane jet heater, where it meets the condensate from the main condenser and stage heaters and

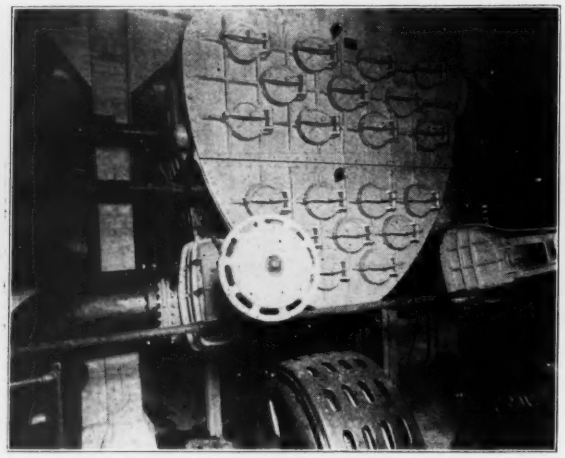


FIG. 14. VACUUM IS MAINTAINED AT 29 IN. BY A SINGLE PASS CONDENSER

FIG. 15. RACKS AND TRAVELING SCREENS KEEP FLOATING TRASH OUT OF THE CONDENSER

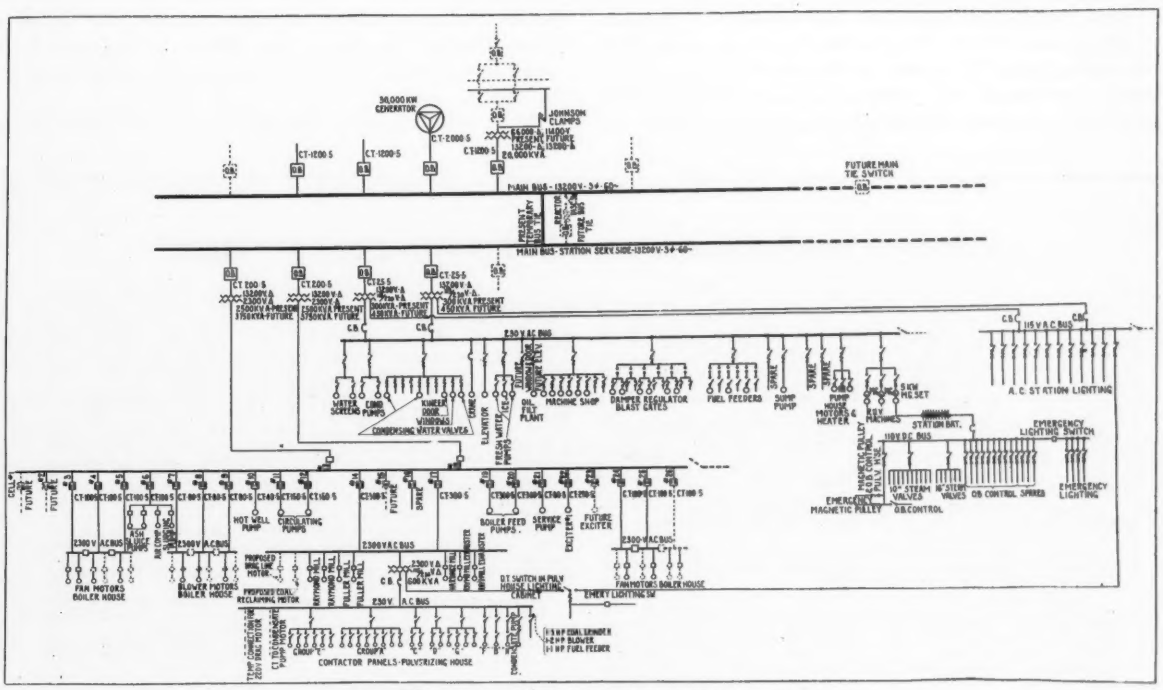


FIG. 16. ELECTRICAL DIAGRAM OF THE PLANT

is then fed to the boilers through the economizers. The plant is designed for a maximum of 5 per cent boiler feed make up.

As previously stated steam used in the main turbine is superheated to a temperature of 660 deg., while that used by the auxiliaries is not superheated. Although this complicates the piping somewhat, if the superheater steam were used by the auxiliaries the exhaust from them would be superheated, requiring expensive piping and insulation without in any way adding to the economy of the equipment. All piping is installed with long sweeping bends to care for expansion.

Turbine Designed for Bleed Feed Water Heating

On the main floor of the turbine room are the generating unit and the dual drive exciter with the necessary instruments and gages. The main unit is a 30,000-kw. General Electric Co. turbo-generator, the turbine consisting of 17 stages arranged for bleeding at the 10th, 13th and 15th stages. Just how this steam is used for heating the feed water is shown in the heat-cycle diagram, Fig. 12, which has been calculated for a load of 26,720 kw. Steam bled from the tenth stage will be used later in a two-effect evaporator to prepare the make-up feed water, which together with the condensate, goes to a jet heater. From the thirteenth stage, steam is bled to No. 3 closed heater which is vented to No. 1 heater. The fifteenth stage is bled to No. 1 heater, the vent from which is connected to the condenser. Steam from the turbine packing gland is used for heating the feed water in No. 2 heater, the vent being connected to No. 1 heater. Air ejectors are used to remove the air from the condenser.

FIG. 17. DISCONNECTING ONE ROD PERMITS THE REMOVAL OF A SWITCH

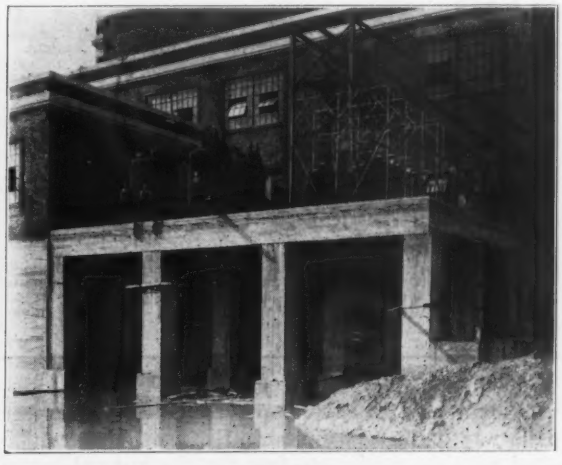


FIG. 18. STATION TRANSFORMERS ARE LOCATED IN THE OPEN AIR

The steam used for this purpose is taken from the auxiliary piping and reduced in pressure to 135 lb. The noncondensable gases, of course, go to atmosphere, but the steam is condensed and returned to the hotwell. The condensate pump takes the water from the hotwell and delivers it through the ejector to No. 1 closed heater, then, on its way to the gland heater, the main condensate is joined with the condensate from the three closed heaters and passes successively through the gland heater, No. 3 closed heater and the jet heater, where it joins the make up water and where the temperature is raised to 212 deg. by the exhaust from the exciter turbine. The boiler feed pumps then deliver the water through the economizers to the boilers.

Aside from radiation, the only sources of heat loss by this arrangement of equipment are through the circulating condenser water and the air discharged by the ejectors.

The condenser was supplied by the Wheeler Condenser & Engineering Co.; it is of the heart shape, single pass type. Here again the company is making an investigation

Principal Equipment in the Middletown Power Station

General

Construction started April 1, 1923; first unit completed December, 1924. Engineering work and construction done by The W. S. Barstow Management Association, Inc.

Ultimate capacity, 200,000 kw.; six units of 30,000 and 35,000 kw.; initial capacity, one 30,000 kw. unit.

Fuel used—pulverized coal, bituminous and river anthracite.

Circulating water taken from Susquehanna River. Incoming temperature range from 32 to 75 deg. F.

Buildings

Area of property 60 acres. Turbine room ultimate dimensions 540 ft. x 56 ft., 60 ft. high. Present dimensions 110 ft. x 56 ft., 60 ft. high.

Boiler room ultimate dimensions 540 ft. long; 2 units 126 ft., 3 units 90 ft. wide and 80 ft. high. Present dimensions 110 ft. x 126 ft., 80 ft. high.

Construction material for turbine and boiler rooms—structural steel frame, brick walls, concrete floors and foundations. Turbine room floor concrete with tile surface. Interior finish—boiler room face brick, painted buff and brown, white ceiling, olive green rails. Boiler room walls red brick. Windows—standard steel sash with wire glass. Ventilators—Robertson stationary type made by The H. H. Robertson Co. Roof—concrete. Skylights located in turbine and boiler rooms. Lighting fixtures—porcelain enameled steel reflectors, 12 500 w. units in turbine room supported from roof trusses.

Boilers

Four installed—Connelly water-tube type, 1477 hp. rating, 14,770 sq. ft. heating surface. 1075 tubes, 4 in. diameter, 3 steam drums 42 in. and 48 in. diameter. Thickness of shell 1.33 to 1.51 in. Shell of each drum in one plate having only one double butt strap longitudinal joint. Steam pressure 350 lb.

Water screens consist of 22 tubes, 10 down comers, 12 uptakes, 4 in. outside diameter, presenting a heating surface of 450 sq. ft.

Elesco superheater made by The Superheater Co., located at end of first pass, 2130 sq. ft. heating surface, ratio of superheating surface to boiler heating surface 1 to 7. Superheat at rating, 175 deg. F.; superheat at 200 per cent rating, 225 deg. F.

Economizers, separate type, manufactured by The Power Specialty Co. and B. F. Sturtevant Co., located in rear boilers, 7776 and 7600 sq. ft. heating surface, respectively. Ratio of heating surface of economizers to that of boilers 0.5. Material used—steel. Rating 50,000 lb. water per hr. at 100 per cent boiler rating and 120,000 lb. per hr. at 250 per cent boiler rating. Temperature of water leaving economizer 320 deg. F. Gas temperature entering 520 deg., leaving 300 deg. Gas temperature difference 220 deg. F.

Average evaporation, 11.5 lb. water per lb. fuel. Heating surface per kw. installed, 1.97 sq. ft. Feed water temperature leaving heater 212 deg. F.

Boiler steam gages—one, 12-in. diameter, on each boiler, made by Brown Instrument Co., with recording instrument in turbine room. Two Stets feed-water regulators on each boiler, manufactured by Williams Gauge Co. Combustion control system motor operated, motor controlled. Scully Steel & Iron Co.'s Everlasting blowoff valves in tandem, 3, 2½ in. on each boiler. Safety valves, 6, 3½ in. on each boiler. Soot blowers, 16 units per boiler, valve-in-head type, manufactured by Diamond Power Specialty Co. Steam flow meters, one on each boiler, manufactured by Bailey Meter Co., located in boiler room. Flue gas thermometers, recording type, furnished by Brown Instrument Co., indicating type by Taylor Instrument Co.

Induced draft equipment—four steel plate fans, 7 ft. diameter, furnished by B. F. Sturtevant Co., driven by 125-hp. General Electric Co. Motors. Capacity 1,180,000 lb. gas per hr.

Pulverized Fuel System

Magnetic separator, manufactured by Dings Magnetic Separator Co., 230 v., direct current generated by motor generator set and storage battery.

Dryers—two Wood, manufactured by Combustion Engineering Corp., and two Fuller-Randolph, manufactured by Fuller-Lehigh Co., vertical type, heated by exhaust steam and flue gas, capacity 6 T. per hr., temperatures maintained 400 deg. F.

Cyclone collectors, 4 main on mills and 2 auxiliaries on Wood dryers, furnished by Combustion Engineering Corp. and Fuller-Lehigh Co., respectively.

Fans—four on mills and four on dryers, furnished by B. F. Sturtevant Co.

Pulverizers—two Raymond, furnished by Raymond Bros., 2 Fuller, furnished by Fuller-Lehigh Co., and 1 Hardinge, furnished by Hardinge Manufacturing Co. Rated capacity 6 T. per hr. each.

Two screw conveyors, 14 in. diameter, 72 ft. long, manufactured by H. W. Caldwell & Sons Co., driven by 15-hp. Allis-Chalmers motors, at 860 r. p. m.

Coal pump—Fuller-Kenyon, manufactured by Fuller-Lehigh Co., driven by 50-hp. Allis-Chalmers motor, at 865 r.p.m.

Pulverized coal bunker over each boiler, 70-T. capacity each, made of steel, concrete lined.

Pulverized coal feeders—three groups of feeders per boiler, Combustion Engineering Corp., driven by 12½-hp. variable speed, General Electric Co. motor.

Burners—vertical fan tail type, 6 per boiler, located over front arch, manufactured by Combustion Engineering Corp.

Pulverized Fuel Furnace

General dimensions 24 ft. 1½ in. wide by 20 ft. deep by 23 ft. high above water screen. Volume 11,000 cu. ft. above water screen. Ratio of furnace volume to boiler heating surface 0.75. Walls 23 in. thick, hollow construction, air cooled, steel casing. Arch furnished by the American Arch Co. Fire brick furnished by Harbison-Walker Refractories Co., A. P. Green and General Refractories Co. Supports casings, etc., furnished by McAleenan Corp. and Connery & Co.

Chimneys

Two, built by General Concrete Construction Co. of reinforced concrete, 200 ft. high, inside diameter at base 18 ft. 2½ in., at top 14 ft. Each chimney serves three boilers. Stack area per thousand feet of boiler heating surface, 3.5 sq. ft.

Coal Handling

Conveying equipment furnished by Link-Belt Co., capacity 75-T. per hr., storage capacity in bunker 500-T., outside storage unlimited. Boiler room bunkers of steel made by Lehigh Structural Steel Co. Conveying equipment driven by Allis-Chalmers motors in system of two 5, one 15, one 25 and one 20-hp. motors. Coal reclaimed by drag scraper. Bradford breaker 9 ft. by 17 ft., 150-T. per hr. capacity, manufactured by the Pennsylvania Crusher Co. and driven by 50-hp. Allis-Chalmers motor. 6-T. weigh larry between raw coal bunker and hoppers over pulverized mills, manufactured by Wilbur G. Hudson Corp.

Pumps

Boiler feed—two 6-in., 4-stage, centrifugal, 1000 g.p.m., 1750 r.p.m., manufactured by the Worthington Pump & Machinery Corp. One 5-in., 4-stage, centrifugal, 350 g.p.m., 2800 r.p.m., manufactured by the Worthington Pump & Machinery Corp.

Service pumps—two 6-in. Worthington, horizontal, split casing, double suction, 1500 g.p.m. at 1750 r.p.m., head 155 ft.

Hot well pumps—two 6-in., special design, 2-stage, centrifugal, 800 g.p.m. against 150 ft. head.

Pumps for sluicing ashes—two 5-in. Worthington, double suction, centrifugal, 550 g.p.m. at 1750 r.p.m.

Feed Water Heating and Treating

Three closed heaters, 273,210 lb. per hr., manufactured by Ross Heater & Mfg. Co. One Cochrane deaerating heater, 500,000 lb. per hr., made by Cochrane Corp.

Water system—Permutit softener, capacity 24,000 gal. per 24 hr., manufactured by the Permutit Co. Water treated daily 15,000 gal. average.

by using two different makes of condenser tubes. Circulating water is drawn from the Susquehanna River through two traveling screens, arrangements being made for recirculation of the water from an artificial bay in extremely cold weather.

of steam for heating the feed water, which is maintained at a temperature of 212 deg.

For driving the exciter either a 300-hp. motor or a 200-kw. steam turbine is used, the change from one to the other being made automatically as in the case of the

Principal Equipment in the Middletown Power Station

Turbo Generators

Curtis steam turbine made by the General Electric Co., speed 1800 r.p.m., 17 stages; weight turbine and generator 22 lb. per kw. Steam pressure at throttle 325 lb. gage, temperature 650 deg. F.

Generator—frequency 60-cycle, 3-phase, 13,200 v., 1640 amp. per terminal, power factor 0.80.

Air conditioning system—Mid-West air filters, capacity 90,000 cu. ft. per min., manufactured by Mid-West Air Filters, Inc.

Exciter—one 200-kw. duplex exciter, driven by a 300-hp. steam turbine and a 300-hp. motor, manufactured by the Terry Steam Turbine Co. Exciter voltage 250. Ratio exciter capacity to generator capacity, 1 to 150.

Condenser

Surface, single pass, manufactured by Wheeler Condenser & Engineering Co., capacity 280,000 lb. steam per hr., spring supports, air removed by air ejectors. Performance—capacity lb. steam per hr. at 29.25 in. vacuum and cooling water at 50 deg. F. is 280,000 lb. Cooling water per lb. of steam, 1.9 lb. Number of tubes, 10,916, diameter, ¾ in., No. 17 gage, 21 ft. 2½ in. long. Total tube surface, 45,000 sq. ft. Sq. ft. tube surface per kw. of prime mover 1.5. Tube packing consists of rolling tube at one end and corset laced at other end. Lb. steam condensed per sq. ft. of tube surface, 6.25 per hr. Overall dimensions 27 ft. 6 in. long, 15 ft. 5 in. wide, 15 ft. deep.

Two circulating pumps, one motor driven, one dual driven, each 36 in. centrifugal, 260 r.p.m., 32,500 g.p.m., manufactured by Wheeler Condenser & Engineering Co. Capacity circulating pumps per kw. installed 2.16 g.p.m. Circulating water system consists of an intake with cross section of 3.4 sq. ft. per 1000 gal. circulating water per min. Two revolving screens, manufactured by Link-Belt Co.

Miscellaneous Equipment

100-T. traveling crane in turbine room, supplied by Manning, Maxwell & Moore.

Steel smoke flues, Connery & Co.

Ash sluice, Allen-Sherman-Hoff Co.

Pipe covering, magnesia used on all surfaces over 180 deg. F., Ehret Magnesia Manufacturing Co.

Piping installed by Benjamin F. Shaw Co.

High pressure steam gate valves, Reading Steel Casting Co.

High pressure steam and water fittings, Reading Steel Casting Co. and Henry Vogt Machine Co.

Low pressure steam and water fittings, Crane Co.

Low pressure steam and water lines, standard steel pipe with Chapman valves.

High pressure steam joints of Vanstone type, square lap joint with grooved faces.

Expansion joint between condenser and circulating water pumps and circulating water discharge, rubber type, made by the United States Rubber Co.

High pressure globe and angle valves, Henry Vogt Machine Co. and Edward Valve & Mfg. Co.

Ash gates, air operated, Allen-Sherman-Hoff Co.

Atmospheric relief valves, horizontal multiport type, 30 in. diameter, located next to condenser on atmospheric relief line, C. H. Wheeler Mfg. Co.

Welded joints used only on small high pressure piping which were screwed and welded.

Gaskets, Clingerit, Inc.

Circulating water pipes and fittings manufactured by Benjamin F. Shaw Co., Crane Co. and Chapman Valve Mfg. Co.

Miscellanenous Instruments

Three Venturi meters, Builders Iron Foundry, capacity 600,000 lb. per hr., used for measuring condensate and boiler feed.

Recording instruments were furnished by Brown Instrument Co. for recording temperature and pressure. For recording temperature and pressures of condensate feed water, steam, etc. Bailey Meter Co. furnished boiler meters for steam flow, air flow, etc., on each boiler.

Leeds & Northrup Co. furnished temperature indicators for generator windings.

Electrical Equipment

Station service transformers—main station auxiliary, duplicate banks, three, 1250 kv.a., 13,200 to 23,000 v., manufactured by the General Electric Co., O. I. S. C. outdoor type. Station lighting and power transformers furnishing current for lighting and motors up to 15-hp., duplicate banks, three, 150 kv.a., 13,200 to 220 to 110 v., General Electric Co., O. I. S. C. outdoor type.

Switching equipment—high voltage, Westinghouse 022, truck type, 2000 amp., 15,000 v. on generator and feeder circuits. Westinghouse 022, truck type, 600 amp., 15,000 v., on station auxiliary transformer banks.

Low voltage 2300 v., Westinghouse, F-3, subway type, non-automatic, F-22, full automatic, oil circuit breakers.

Switchboard—three panels, 66 kv., one 114 kv., manufactured by Metropolitan Power Co., of black marine finished slate.

Pipe supports, bus and cable supports of porcelain post type, manufactured by Standard Underground Cable Co., Safety Insulated Wire Co., Hazzard Wire Co. and American Steel & Wire Co.

Transmission voltage, 66 and 114 kv.

Supporting towers of steel, 70 ft. high, spans 600 to 2400 ft., inculators of the suspension type, manufactured by the Ohio Brass Co.

Storage battery, one 60-cell for switching and emergency type, manufactured by Philadelphia Storage Battery Co.

Turbine signal equipment located in switchboard room, turbine room, boiler room and superintendent's office, manufactured by Payne Dean Ltd.

Safety switches furnished by Westinghouse Electric & Mfg. Co.

Station lighting, safety enclosed panels at 110 v., supplied by Westinghouse Electric & Mfg. Co.

Switchboard instruments furnished by the Weston Electrical Instrument Co.

Graphic recording instruments by the Esterline-Angus Co. and recording watthour meters by the Westinghouse Elec. & Mfg. Co.

Electric Motors for Station Auxiliaries

Dual-drive exciter	300 hp.	1200 r.p.m.	2200 v.
Circulating pumps	250 hp.	300 r.p.m.	2200 v.
Hotwell pumps	50 hp.	1800 r.p.m.	2200 v.
Condensate pumps (heaters)	20 hp.	1800 r.p.m.	220 v.
Boiler feed pumps	350 hp.	1800 r.p.m.	2200 v.
Service pumps	100 hp.	1800 r.p.m.	2200 v.
Sluicing system pumps	30 hp.	1800 r.p.m.	2200 v.
Sump pump	5 hp.	1800 r.p.m.	220 v.
Fuel feeders	12½ hp.	1650/550 r.p.m.	220 v.
Blowers for fuel feeders	60 hp.	1800 r.p.m.	2200 v.
Cindervane fans	100 hp.	600 r.p.m.	2200 v.
Air compressor	50 hp.	1200 r.p.m.	2200 v.
Coal Handling Equipment			
Apron feeders	5 hp.	900 r.p.m.	220 v.
Apron conveyor	15 hp.	900 r.p.m.	220 v.
Bradford breaker	50 hp.	900 r.p.m.	220 v.
Belt conveyor	5 hp.	900 r.p.m.	220 v.
Elevator conveyor	25 hp.	900 r.p.m.	220 v.
Distributing conveyor	20 hp.	900 r.p.m.	220 v.
Shuttle conveyor to storage	5 hp.	900 r.p.m.	220 v.
Pulverizer Equipment			
Raymond mills	100 hp.	450 r.p.m.	2200 v.
Fuller mills	100 hp.	400 r.p.m.	2200 v.
Hardinge mill	100 hp.	720 r.p.m.	2200 v.
Exhausters, Raymond	50 hp.	1200 r.p.m.	2200 v.
Exhausters, Fuller	30 hp.	720 r.p.m.	220 v.
Separator, Hardinge	20 hp.	900 r.p.m.	220 v.
Feeders, Hardinge	3 hp.	900 r.p.m.	220 v.
Screw conveyors	15 hp.	900 r.p.m.	220 v.
Fuller-Kenyon pumps	50 hp.	900 r.p.m.	220 v.
Cindervane fans	25 hp.	720 r.p.m.	220 v.
Air compressor	50 hp.	1200 r.p.m.	220 v.
Weigh larry	7½ hp.	800 r.p.m.	220 v.

Two circulating pumps are installed, one of which is a spare unit. These are centrifugal pumps, one being driven by motor only, while the other is a dual unit driven by either a motor or a steam turbine, the change of drive is made automatically, depending upon the need

circulating pumps. This unit furnishes direct current at 230 v. to the field of the main generator which delivers three-phase alternating current at 13,200 v. Air for cooling the generator is taken from the basement and passed through Midwest air filters located in openings in the

foundation under the generator. The heated air is carried in ducts to the boiler room where it is used to support combustion.

Electrical Features

The generator feeds the main bus through an oil circuit breaker. At present this bus is tied solidly to the station service side but the permanent arrangement will be to connect the two busses by a disconnect, a reactor and an oil breaker. The station transformers take their current from the station service side of the main bus. Two of the four station transformers step the voltage down to 2300 for use on the motors of 30 hp. and above, while the other two carry secondary voltages of 115 and 230 for lighting purposes and running the smaller motors. These transformers are located outdoors on the balcony beside the screen house. They are arranged in duplicate, as will be noted in the one-line diagram, Fig. 16. The auxiliary switches are of the truck type designed for push button control from various points about the plant. These switches are interchangeable and a spare is always available at a moment's notice.

At present, the plant feeds three 66,000-v. transmission lines, one 50,000 and one 7500-kv.a. lines to the Middletown substation and one 20,000-kv.a. line to Reading. The latter will be changed to 114,000 v. later on. Underground cables carrying current at 13,200 v. connect the main bus to an outdoor transformer station where the voltage is raised to that carried on the transmission lines.

The design, construction and operation of this plant has all been done by The W. S. Barstow Management Ass'n., Inc., of which E. M. Gilbert is vice-president and chief engineer, and J. A. Powell is mechanical engineer.

Conditions Affecting the Use of Preheated Air

Greater Pressure Is Required to Give Same Weight as With Cold Air

PREHEATING THE AIR needed for combustion is advocated by many as being a more important consideration than the use of economizers. It is at least just as necessary if maximum efficiency is to be obtained.

Manufacturers of combustion equipment are therefore finding it necessary to revise their methods of computing the volume, weight and pressure of the air needed in order that the proper size and speed of fan will be provided.

THEORETICAL WEIGHT OF AIR FOR COMPLETE COMBUSTION ALMOST A CONSTANT PER 10,000 B.T.U. IN ANY FUEL

FUEL	Composition-moisture included					Moist. per lb. fuel	B.T.U. per lb. fuel as fired	Air per lb. fuel lbs.	Air per lb. Combustible lbs.	Air per 10,000 B.T.U. in fuel lbs.
	C	H	O	S	Ash					
North Dakota Lignite	0.394	0.068	0.438	0.007	0.093	0.362	6,700	5 0	9 2	7 54
Colorado Lignite	.578	060	310	004	048	207	9,941	7 5	9 9	7 53
Illinois Bituminous	609	058	192	037	104	127	10,989	8 4	10 8	7 66
Ohio Bituminous	705	054	112	029	100	052	12,733	9 7	11 2	7 63
Pa. Bituminous	757	054	103	012	074	035	13,700	10 3	11 3	7 50
Pa. Semi-Bituminous	807	043	032	014	104	012	14,096	10 8	12 0	7 65
W. Va. Semi-Bituminous	843	047	052	007	051	031	14,088	11 2	12 1	7 65
Pa. Anthracite	732	028	041	008	171	021	12,472	9 6	11 9	7 66
Cal. Crude Oil	866	116	000	008	010	000	18,565	14 1	14 2	7 59
										Av. 7.65

In stoker practice, when using forced draft, it was formerly assumed that the pressure varied as the square of the velocity since it was believed that fuel bed conditions produced a constant orifice. Recent experience, however, has shown that the air pressure does not increase as the square of the velocity, but is believed to be a straight line function, or nearly so. By this is meant that the pressure required varies directly as the volume.

Research on the combustion of fuels with preheated air may disclose information not now known, but for the present we must assume that the gain in efficiency due to its use is merely that represented by the sensible heat returned to the furnace in the air supply. Ordinarily it requires from 12 to 15 lb. air per pound of coal to insure good results and if this air is heated from a room temperature of 70 deg. F. to 300 deg. F., there will be a 230 deg. rise in temperature, and for each pound of coal there will be returned to the furnace: $15 \times 0.24 \times 230 = 830$ B.t.u.

This will obviously cause an increase in overall efficiency, but unless the CO_2 content of the flue gases is different or the ash pit loss different with preheated air than with cold air it will require the same number of pounds of air to burn a given quantity of coal in each case. The volume and pressure of the air required, however, will be different and the problem is to determine what these values will be.

Data shown in the table have been worked out for representative fuels of all parts of the country and show that the theoretical weight of air for complete combustion is practically a constant per 10,000 B.t.u. in the fuel.

Volume of Heated Air Changes in Proportion to Absolute Temperature

If we assume that 5000 lb. coal, with a heat value of 12,000 B.t.u. per lb., are to be burned per hour with 50 per cent excess air, the quantity of air required will be: $7.65 \times 1.2 \times 1.50 = 13.75$ lb. per lb. of coal or 68,750 lb. air per hour. At a temperature of 70 deg., air has a volume of 13.35 cu. ft. per lb., and so 5000 lb. coal will require $68,750 \times 13.35 = 917,813$ cu. ft. of air per hour or 15,297 cu. ft. per minute.

When air is heated the volume increases in proportion to the ratio of absolute temperatures. The absolute temperature of air at 70 deg. is 530 deg., and for air at 300 deg., it is 760 deg. The ratio of 760 to 530 is as 1.43 to 1. We must accordingly multiply 15,297 by 1.43 which gives 21,975 cu. ft. per min. as the volume required when using preheated air.

Air Pressure Dependent on Combustion Conditions

The question of the pressure required in forced draft practice is important and yet there is no definite rule by which we can determine the exact pressure required for any given combustion rate. The kind of fuel, type of stoker, moisture in the fuel, fineness of the fuel and thickness of the fuel bed are some of the main factors which determine the pressure needed to give desired results. Long experience has given the stoker companies fairly reliable information when burning fuel with air at ordinary temperatures so that the curve shown in Fig. 1 may be taken as a rough indication of pressures required when burning bituminous screenings.

If we find that with the conditions under which we are operating that a combustion rate of 30 lb. per square foot of grate requires an air pressure of 4.1 in., then with a given temperature of heated air, we must decide what the pressure must be. With conditions as previously stated, the

velocity of air through the stoker is increased in proportion to the increase in volume, which was shown to be in the ratio of 1.43 to 1. This increase in velocity is due to the lesser density of the air without any increase in pressure. But in order to force through enough air by weight to burn the coal, there must be an increase in pressure which is determined as follows: Divide the square root of 760 by the square root of 530. This gives 1.195, since the increase in velocity due to the decrease in density without change in pressure is in the ratio of 1.195 to 1. Since the total increase in velocity must be in the ratio of 1.43 to 1, next divide 1.43 by 1.195 and the result, 1.195, will be the factor by which the air pressure at 70 deg. must be multiplied if the proper weight of preheated air is to be supplied. Since 4.1 in. pressure must be used with cold air when it is heated to 300 deg., we must multiply 4.1 by

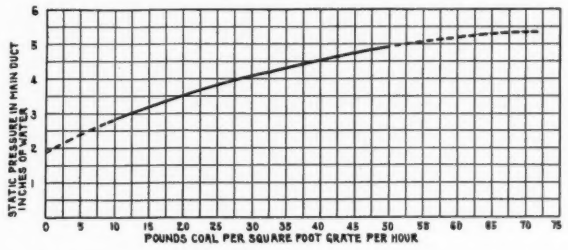

STATIC PRESSURE IN MAIN DUCT INCHES OF WATER
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
POUNDS COAL PER SQUARE FOOT GRATE PER HOUR

FIG. 1. STATIC PRESSURE FOR COLD AIR WITH AVERAGE BITUMINOUS COALS

1.195. We then get 4.9 in. as the required pressure with preheated air.

If we were to assume that the air from the fan is constantly being delivered through an orifice of unvarying size, there would be a constant resistance at any given air density and the pressure required would vary as the square of the volume. But in stoker practice the problem is complicated by changes in the fuel bed, so that, until further research is devoted to the subject, we must hold to the "straight line law," which assumes that the pressure required varies directly as the volume.

Handy Formulas for Computing Air Problems

It was previously pointed out that with the same pressure with preheated air as with cold air, there would not be sufficient weight of hot air to burn the fuel. If we express the factors in the problem as follows:

p = pressure necessary with cold air.
P = pressure necessary with hot air.
W = weight of cold air required to burn the coal.
W_1 = weight of hot air put through the fuel bed by the same pressure as for cold.
W_2 = weight of hot air required to burn the fuel.
d = density of cold air.
d_1 = density of heated air.

Then, for the same pressure (p), we have,

$$W_1 = W \frac{d_1}{d} \qquad (1)$$

But since W_1 is not sufficient to burn the coal and assuming the straight line law as correct, then

$$P = p \frac{W_2}{W_1} \qquad (2)$$

Since $W \frac{d_1}{d}$ is equal to W_1, we can substitute in equation (2) and will then have $P = \frac{p\,W_2}{W \frac{d_1}{d}}$

In computing air volumes, weights and pressures, a handy formula is $W = 0.0758 \times \frac{B}{30} \times \frac{520}{T + 460}$

where, W = weight per cubic foot at the desired pressure and temperature, B = barometric pressure, inches mercury plus observed air pressure, inches mercury, T = air temperature. The formula $\frac{1.00}{W}$ will give the number of cubic feet per pound of air at the observed temperature.

In figuring on installations using preheated air, it is necessary to know what size of air duct will be needed. If we assume a combustion rate of 30 lb. per square foot of grate per hour and 15 lb. air required per pound of coal, 450 lb. air will be needed per square foot of grate per hour. If air is supplied at 300 deg., the volume of 1 lb. air will be 19.2 cu. ft. Multiplying 450 by 19.2 gives 8640 cu. ft.

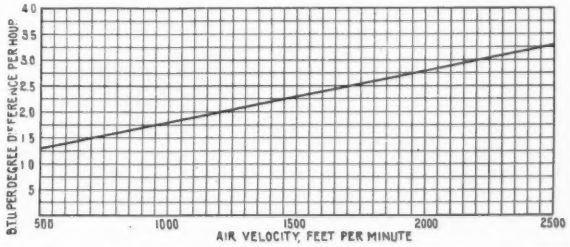


FIG. 2. RATE OF HEAT TRANSFER IN B.T.U. PER HR. PER DEG. DIFFERENCE IN TEMP. FOR AIR HEATERS

of air required per square foot of grate per hour. With the effective velocity at the grate surface about 8.0 per cent of that in the main duct, and assuming the static pressure as 4.9 in. in the main duct, the velocity at the grate surface will be about 2000 ft. per min., or 120,000 ft. per hr. Now, if we divide 8640 by 120,000, we obtain 0.072 sq. ft. of duct needed for each square foot of grate area, when using preheated air under the above conditions.

It is of interest to note the approximate rate of heat transfer with either cast iron or steel heaters. This is shown in Fig. 2. It does not apply to any particular condition or style of heater but will give a general idea of the rate of heat exchange.

The Ohio Committee on the Relation of Electricity to Agriculture, Columbus, Ohio, is perfecting arrangements for an early survey of farm districts in different parts of the state, with view to electrification of such rural communities. The committee is composed of representatives of the Ohio State University, the State Grange, Ohio Farm Bureau Federation, public utility companies and electrical equipment manufacturers. It has for its fundamental object a study of the benefits that electric energy brings to rural life. It is stated that Ohio has 256,000 farms; of this number, 33,000 farms, or 12.9 per cent, have electric service from one source or another. P. H. Potter is executive secretary of the committee.

Progress in Mechanical Stoker Practice

LONG FUEL BED, DEEP ASH WELL, CONTROLLED ZONES OF DRAFT, WATER-COOLED WALLS AND HIGH SETTING INCREASE EFFICIENCY. BY JOSEPH G. WORKER*

SOME 12,000,000 hp. of stokers are in use in the United States today, with installation proceeding at the rate of 750,000 hp. a year. These plants are burning around 200,000,000 T. of coal a year and while we are all much concerned with a saving of 1 or 2 per cent in future plants, it should not be forgotten that this is little as compared with the saving that can be made by building up the efficiency of the older plants. In these savings of 8 to 10 per cent and in some cases as high as 25 per cent can be made.

As an example of modern stokers of underfeed type, take those at the Kearny station of the Public Service Production Co. of N. J. They are 24 ft. 10 in. in depth, 27 ft. 9 in. wide and 16 ft. 3 in. high. As shown in Fig. 1, the

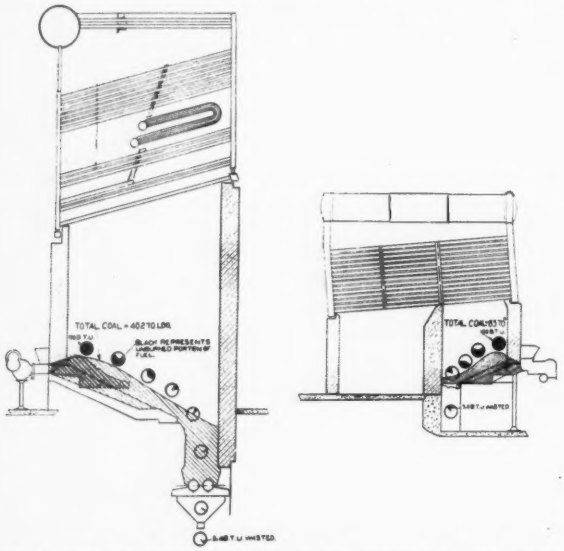


FIG. 1. OLD AND MODERN UNDERFEED STOKER PLANTS SHOWING DEVELOPMENT IN SIZE

rotary-discharge ash pit is almost equal in depth to the total length of an old type stoker. This makes it possible to reduce the loss from combustible in the ash as shown by the black parts of the circles, which represent the proportion of unconsumed combustible in the coal at various points along the stoker. With the old stoker, some 4.2 per cent of the heat value of the coal was found in the refuse; with the modern long stoker, as at Hell Gate, this is reduced to 0.4 of 1 per cent.

The chief advantage of the long stoker is, however, the ability to burn more coal per foot of furnace width and at higher efficiency. In an 11-hr. test at Hell Gate an average of 461 per cent of boiler rating was reached with the maximum at 603 per cent. It follows that high, narrow boilers can be used with greatly increased heat-absorbing capacity per square foot of floor space. The single deep stoker is easy to operate, requires small power and costs a minimum for maintenance. In the original Hell Gate installation, two 14-retort stokers were used, each 17 tuyeres deep with a double rotary ash discharge between them and a depth between end walls of 19 ft. 1 in. In the new installation, a single stoker is used with 33 tuyeres and single rotary discharge. It is longer than the first setting but the depth between end walls is 15 ft. 6 in. and it does away with the area of low combustion under the middle of the tubes.

One of the most important developments in modern practice is the regulation of the velocity of fuel and air in

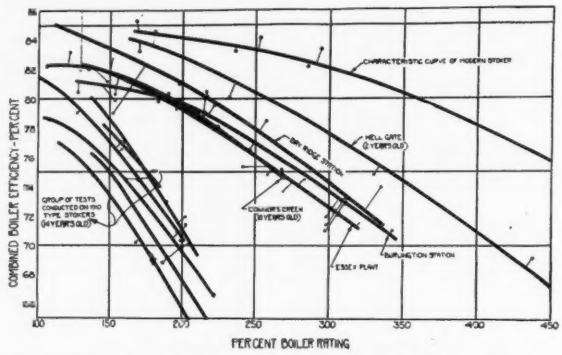


FIG. 2. PERFORMANCE OF OLD AND NEW TYPE STOKERS AS TO EFFICIENCY AND FUEL BURNING RATE

different zones of the fuel bed. All parts have been proportioned with respect to the progress of the fuel from the point of entry until its discharge as ash and to give the right amount of air at each point in this progress. With the deep ash well, the long stoker effectively controls the feed of fuel both horizontally and vertically.

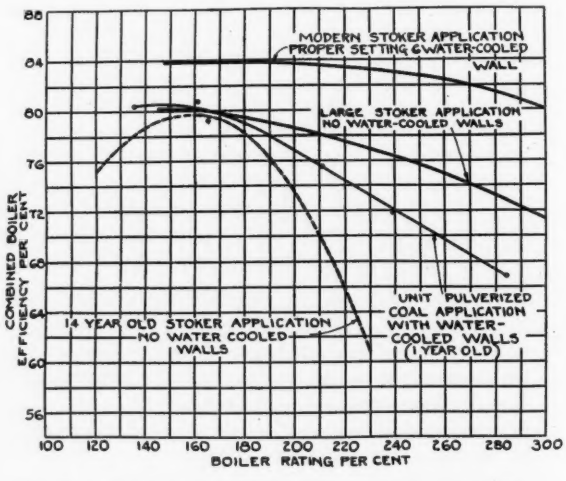

MODERN STOKER APPLICATION PROPER SETTING & WATER-COOLED WALL
LARGE STOKER APPLICATION NO WATER-COOLED WALLS
14 YEAR OLD STOKER APPLICATION NO WATER COOLED WALLS
UNIT PULVERIZED COAL APPLICATION WITH WATER-COOLED WALLS (1 YEAR OLD)
COMBINED BOILER EFFICIENCY PER CENT
BOILER RATING PER CENT
100 120 140 160 180 200 220 240 260 280 300

FIG. 3. COMPARISON CURVES FOR OLD AND NEW TYPE STOKERS IN OLD AND MODERN SETTINGS

Curves of Fig. 2 show the advance that has been made in burning of coal at high rates and high efficiencies. The left hand group of curves are from stokers 14 yr. old of the short bed type; next come a group about 10 yr. old, showing marked improvement; then a curve from the Hell Gate plant, 2 yr. old; and finally a curve showing the characteristics of the modern stoker. From these, it can be

*From a paper read before the Engineers' Society of Western Pennsylvania.

seen what can be gained by modernizing the older plants and including modern heat saving methods in their equipment.

In many cases, comparison is made between a pulverized fuel unit which is installed to see "what it can do" and an old stoker fired unit. Obviously, the new unit will be up to date in the matter of setting and heat saving devices such as water-cooled walls, economizers and, possibly, air preheaters. It is of interest to note that as between two pulverized fuel plants, one having ordinary solid walls, no water screen, no economizer and no combustion control, the other having all these devices, the gain in efficiency was 7 to 8 per cent in favor of the latter. Therefore, comparison of an old stoker-fired unit with a modern powdered-fuel unit is hardly a comparison of the merits of the two systems of burning fuel. Contrast between the old type stoker and the new will show as great difference as is seen in Fig. 3. In that are given performance curves for a 14-yr. old stoker, a large stoker without water-cooled walls and a modern stoker with all the latest devices for heat saving and heat recovery. Incidentally there is shown the curve for a pulverized fuel installation a year old.

In the past, mechanical stokers have been bound by restrictions, which are being removed or eliminated so that full possibilities can now be developed. Drying of coal, heat recovery from the furnace walls, large furnace volume for burning gases, with full complement of heat recovery devices are now being used. These will make for maximum output, highest efficiency and best plant economy. If all stoker plants were brought up to modern standards, the saving would be tremendous.

Methods of Obtaining a Heat Balance---II*

If Two Turbines Bleed to One Heater the Result May Be That One Turbine Will Furnish All the Steam

THIS IS THE second and last article of this series on the subject of heat balance hook ups. The first article appeared in the July 1 issue.

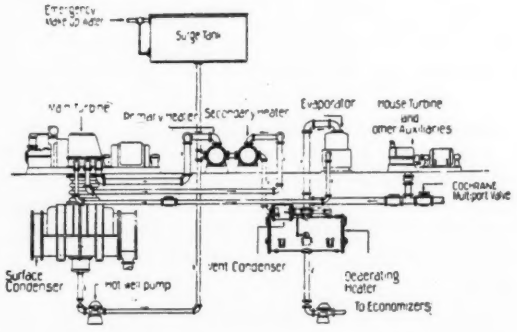


FIG. 1. THREE FEED CONNECTIONS ARE MADE TO THE TURBINES AT SPRINGDALE STATION

At Springdale Station No. 2, West Penn Power Co., is the arrangement as shown in Fig. 1. Three bleed connections are made to the turbine. The low pressure and intermediate pressure connections supply steam to the closed heaters and the high pressure bleed supplies steam to the makeup evaporator. Vapor from the evaporator, together with the house turbine exhaust, is used in the deaerating heater. Backflow from the evaporator to the main turbine and from the deaerator to the house turbine is prevented by the installation of steam check valves. The house turbine is protected by an atmospheric relief valve.

Exhaust from the auxiliaries may furnish steam to a double effect evaporator which in turn supplies the steam for the deaerating heater, as shown by Fig. 2. In a layout of this kind, it is probable that the auxiliaries will supply more heat than can be transmitted to the evaporator tube service, the result being that the pressure at the inlet to the first effect will rise. This can be overcome by the use of a flow valve fitted to the bypass around the evaporator so that excess steam can flow directly from the exhaust line to the deaerating heater. It may also occur that the condensate is so great that the heat available in the auxiliary exhaust will not give the desired temperature. To take care of this condition the heater may draw

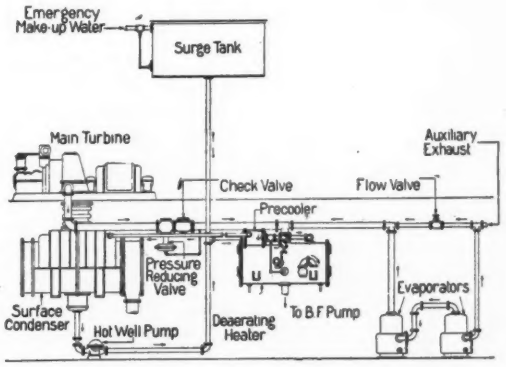


FIG. 2. AUXILIARY EXHAUST STEAM MAY BE USED IN A DOUBLE EFFECT EVAPORATOR

a supplementary supply of steam through a pressure reducing valve which is tied in with a bleeder connection on the main turbine. Here again a check valve should be used to protect the main unit against backflow of steam.

In Fig. 3, steam from a bleeder connection on the main turbine flows to the deaerating heater and that steam which is vented from the deaerating heater flows to a lower stage of the same turbine. Here a vent condenser is not required because there is no ejector or air pump and the heat available in the mixture can be used to generate power in the main turbine. As in previous cases, it is advisable to install a check valve between the heater and the turbine. Use of the deaerating heater of the surface re-boiler type is shown in Fig. 4. In this type of heater the water in the storage space is scrubbed by the steam which is set free from the surface of the tubes. These tubes are internally heated by steam supplied at high pressure and temperature from a bleeder connection on the main unit. The feed pump draws water from the deaerating heater and forces it through a closed heater, which is supplied with steam from the same bleed connection. The water is then heated

*Abstracted from "Heat Balance Hookups," copyrighted by the Cochrane Corporation, Philadelphia.

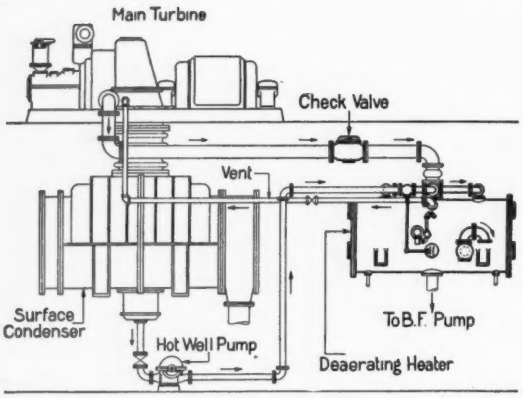


FIG. 3. HEATER VENT MAY BE CONNECTED TO A LOW STAGE OF THE TURBINE

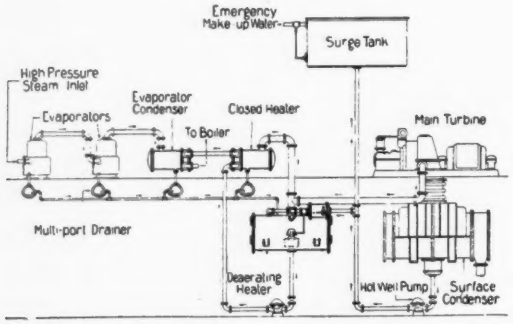


FIG. 4. DEAERATING HEATERS OF THE SURFACE REBOILER TYPE ARE SOMETIMES USED

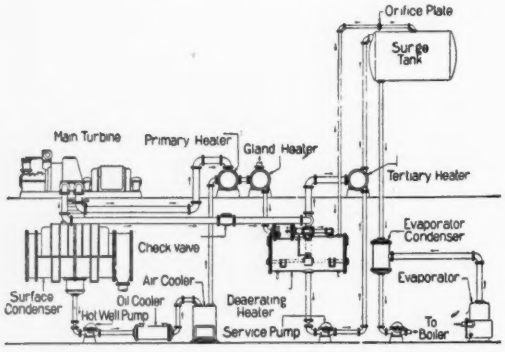


FIG. 5. FEED WATER IS OFTEN PARTIALLY HEATED BY AN OIL AND AIR COOLER

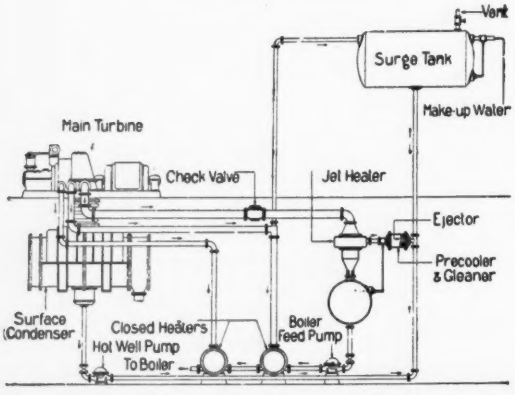


FIG. 6. INGRESS OF AIR TO THE CONDENSATE CAN BE PREVENTED BY BLANKETING THE SURGE TANK WITH STEAM

in the condenser of an evaporator which uses high pressure steam.

Use of a deaerating heater with surface type re-boiler and enclosed heater, both receiving steam from the same bleed connection, is shown in Fig. 5. The feed water in this case has been partially heated before it reaches the deaerating heater by an oil cooler and air cooler and a primary flow heater receiving steam from a low pressure stage of the main turbine. After leaving the deaerating heater the water passes to a closed heater and then to a closed elevated surge tank in which a vapor pressure corresponding to the water temperature is maintained by venting vapor through an orifice back to the deaerating heater. Feed water passes from the surge tank through the condenser of the make-up evaporator and then to the boiler feed pump.

Figure 6 illustrates another scheme wherein the main turbine is bled at three points. The first, or lowest pressure point, is bled to a primary jet heater and the second and third points to a closed heater. Feed water is taken from the condenser hot well and pumped to an elevated closed surge tank, which is blanketed with steam from a connection to the intermediate turbine bleed, the tank being vented to atmosphere. This is an effective way to prevent the ingress of air to the condensate. If it is desired to eliminate all of the air, a deaerating heater should be substituted for the jet heater without any changes being made in the hook-up. Here again a check valve is advisable between the jet heater and the turbine bleed connection.

Three-stage extraction is shown in Fig. 7. In this case the intermediate heater is of the direct contact deaerating type which receives steam from a stage in which the pressure is just above that of the atmosphere and make-up is discharged to the main condenser. This arrangement may be changed somewhat and the make-up discharged into the surge tank.

It is also possible to use extracted steam from four different stages of the main unit, as shown in Fig. 8. Low pressure extraction is taken into a surface heater. The next higher extraction furnishes steam to the heating and deaerating unit, which consists of a surface heater and a deaerating type heater with the evaporator tubes in the water space. The surface heater is supplied with steam from the next higher stage extraction and the highest pressure extraction furnishes steam to an evaporator, the vapor of which is used in the surface heater which also receives steam from the next lower bleed point. With this arrangement the evaporator will be run at a pressure near

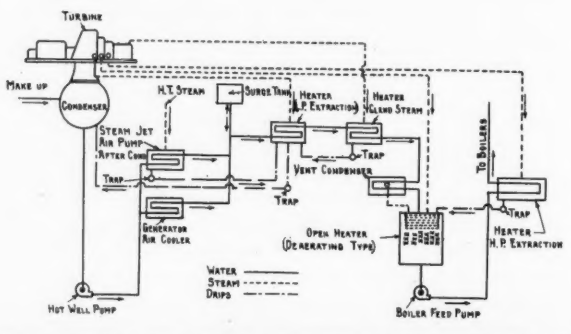


FIG. 7. STEAM JUST ABOVE ATMOSPHERIC PRESSURE MAY BE USED IN THE INTERMEDIATE HEATER

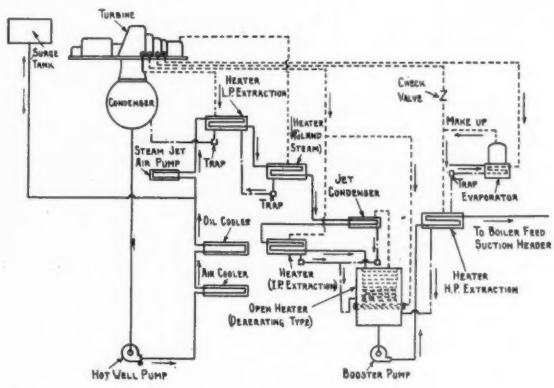


FIG. 8. THIS ARRANGEMENT PROVIDES FOR STEAM EXTRACTION FROM FOUR DIFFERENT STAGES

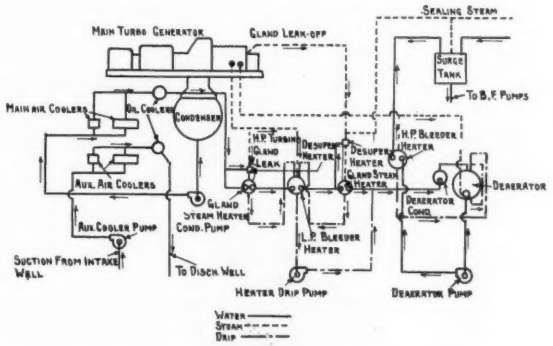


FIG. 9. SOME SCHEMES PROVIDE FOR BOTH A MAIN TURBINE AND ALSO A SMALLER HIGH PRESSURE TURBINE

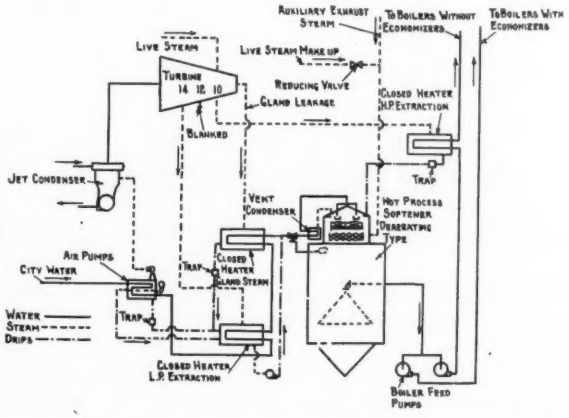


FIG. 10. WHEN JET CONDENSERS ARE USED ALL THE FEED WATER IS MAKE-UP

that of the next to the highest bleed point on the main unit.

Figure 9 shows a system wherein the main unit is bled from two points and there is also a smaller high pressure turbine and two gland heaters, one for the high pressure turbine and one for the main turbine. Steam from the low pressure bleed connection on the main turbine passes to a surface heater. The deaerator and surface heater both receive steam from the high pressure bleed point on the

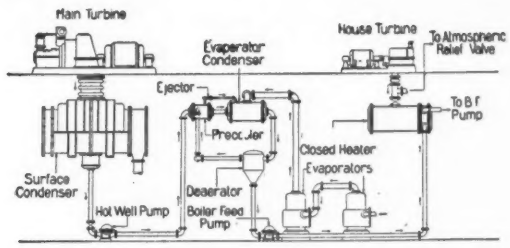


FIG. 11. IT IS OFTEN DESIRABLE FIRST TO HEAT THE CONDENSATE IN THE PRE-COOLER OF THE DEAERATOR

main unit. Hot water is stored in the surge tank to which is connected the make-up line.

It is possible to use jet condensers even though the turbines are large. This is shown in Fig. 10. This amounts to having all of the feed water make-up and is generally used where the water is fairly good. From an operating standpoint, it has been found desirable to treat the water chemically in some sort of a combination apparatus of the softener and deaerating type. Ordinarily steam would be derived from the steam driven auxiliaries and a connection can be made so that live steam make-up may be used, if necessary.

The arrangement shown in Fig. 11 is that in which the water from a hot well is heated first by the pre-cooler of the deaerator and by the evaporator condenser. It is flashed down in the deaerator and heated by the condenser of the house turbine before it passes to the boiler feed pump. It is evident, of course, that the loss of temperature in flashing reduces the temperature head available to the evaporator. That is, where a deaerator heater is used the evaporator could exhaust directly into it. This would have the advantage of a greater temperature head, assuming the boiler feed water to leave the deaerator at the same temperature in either case.

Ordinarily feed water systems are laid out on the unit principle, that is, each main turbine having its own set of feed water heaters. It is not considered good practice in many cases to bleed from two turbines into one heater, because of the fact that the two turbines would seldom have the same pressure at the bled stage. This would mean that either one turbine or the other would be furnishing all the steam. Double unit installations of heaters have been made and in other cases cross connections with valves have been provided. In industrial plants it is seldom the case that the requirements for hot water and the supply of exhaust steam balance each other.

Constant supply of hot water can be obtained by providing a suitable storage. This can be arranged for by placing a heater over the storage tank and fitting it with a relief valve so that back pressure can be carried. Water may then be admitted through two branch pipes, one of which should be controlled by a valve connected to a float near the bottom of the storage tank. This will insure a supply of boiler feed water, regardless of the steam supply. Two valves should be arranged in the other branch, one being automatically opened as the steam pressure in the heater rises, thus admitting water to be heated whenever there is steam available. The second valve in this branch should be of float control at a high level in the storage tank so as to shut off the water when the tank is full.

Packing Glands for Steam Turbines

STEAM LEAKAGE PAST THE GLANDS IS AN ANNOYANCE WHICH CAN BE OVERCOME. BY J. Y. DAHLSTRAND

SUBSTANTIAL PROGRESS has been made in the last few years in perfecting the mechanical design of steam turbines, both in larger sizes and for small turbines. Improvements have become necessary in order for the small steam turbine to retain its position as an important prime mover, for while the fuel economy obtainable through the use of non-condensing turbines to furnish steam for heating and industrial purposes has given the turbine a great advantage in the majority of plants, small mechanical imperfections have made operation of turbines in some cases less reliable than desired.

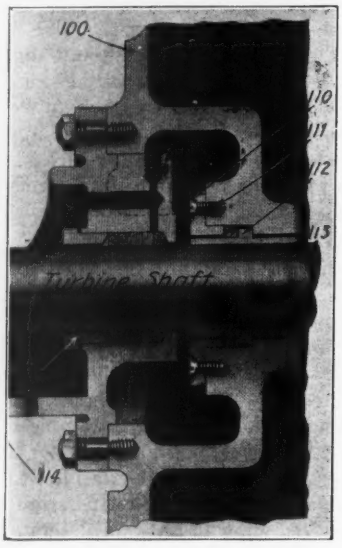


FIG. 1. BRONZE BUSHINGS AND SOFT PACKING WERE OFTEN USED

Certain practical points have had to be worked out and as stated, rapid progress has been made on these points in the last few years.

One of the things which have caused considerable annoyance in small steam turbines has been the glands. This applies particularly to non-condensing turbines using high back pressure or turbines of the multi-stage type using a high pressure in the first stage. The actual loss of steam through the glands is of course in general, negligible, but the annoyance of having steam and water coming out of these glands at all times makes the operation unsatisfactory. This is particularly true for marine work where auxiliary turbines are generally operated condensing while at sea and non-condensing while in port. As long as the turbine is operated condensing, there is no trouble from steam leakage but when changing over to non-condensing some types of machines have a cloud of steam around them at all times which is a serious matter in the ship's engine room. Considerable study has been given to this matter by the U. S. Navy and by shipbuilders and it is their opinion that improved turbine glands have been one vital need of the small steam turbine. This applies equally well in stationary plants.

In practically all the early types of small steam turbines the glands consisted of soft packing made of a graphited rope or of a metal graphite compound. For single stage turbines operating near atmospheric pressure this type of packing gland was usually quite satisfactory unless the shaft diameter was too large. In some cases the shaft diameter was small enough so as to make the turbine run through a critical speed while going up to its operating speed and in such cases the soft packing gland was not satisfactory.

As multi-stage turbines came into use it was found necessary to pack them with something in addition to the soft packing. Bronze bushings such as shown in Fig. 1, were included inside of a soft packing gland, a leakage pipe being extended into the space between the bronze bushing from a low pressure stage. One or two such bushings would sometimes be used and sometimes two leakage pipes provided.

Soft packing glands were not always sufficient to hold vacuum and so a bronze bushing was sometimes also

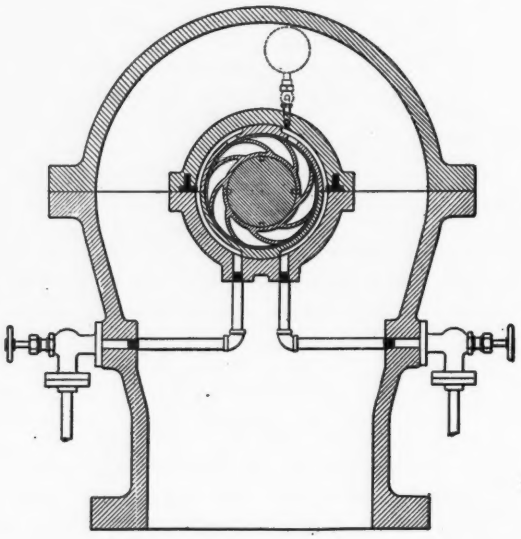


FIG. 2. WATER PACKED GLANDS HAVE PROVED EFFECTIVE

included in the exhaust end as shown in Fig. 1, to which a certain amount of steam was bled from a stage having approximately atmospheric pressure, thus sealing this gland. Bronze bushings were usually made floating to prevent riding on the shaft, which would have been especially bad on a multi-stage turbine.

GLANDS SOMETIMES USED IN COMBINATION

Some builders of small turbines used a labyrinth gland with one stationary part on it. This was satisfactory and is still used. This construction makes necessary a stiff shaft machine as otherwise clearances will have to be too large to accommodate the shaft while going through critical speeds. These labyrinth glands were usually also provided with a soft packing gland at the end to prevent moisture from going along the shaft to the bearings.

Some manufacturers have also used a water packed gland consisting of a centrifugal runner mounted in a

casing as shown in Fig. 2. This runner takes a certain amount of water and builds up around itself a pressure sufficient to prevent steam leakage.

While this construction is excellent for large generator units, it is rather undesirable for turbines operating at low speeds, as many of these small machines have to do, on account of the size of the impeller necessary. It is further undesirable on account of the great amount of condensation taking place around the gland and also the water consumption is often an important item.

As turbine speeds were increased, shaft diameters of smaller machines also were increased. Steam pressures and steam temperatures became higher and a different type of a packing gland was necessary. This brought about the carbon packing gland, a common type of which is shown in Fig. 3. This generally consists of a series of carbon rings placed in grooves in the packing case and held together either by means of a garter spring or by means of springs mounted on the carbon segments pressing against the interior of the packing case.

Advantage of the carbon gland consists principally in the light weight of the material which allows a floating ring of considerable dimensions without danger of scoring the shaft, the friction coefficient of carbon and physical

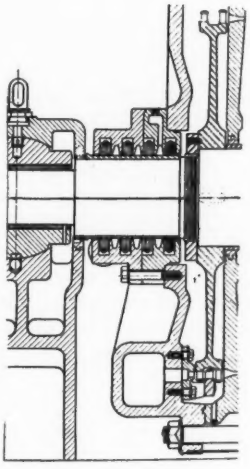


FIG. 3. CARBON PACKING RINGS ARE OFTEN USED

qualities which give a high polish to the carbon surface at points where it touches the shaft, thus insuring a close fit on the shaft.

Certain difficulties have been experienced with carbon packing, such as cutting of the shaft which is invariably caused by too coarse grain carbon. Breakage of carbon, which if not caused by mechanical conditions, bringing about vibration of the machine and consequent jamming of the carbon, may be due to incorrect binder in the material. Certain manufacturers of carbons have succeeded in making a ring from a fine grain carbon powder with a binder which makes the final product combine hardness and toughness.

Early carbon packing glands had close clearance both on the sides of the carbon and on the shaft. Later on it was found that with steam encountered in some plants the carbon would become baked into the grooves in the gland, thus interfering with the movement of the rings and soon causing breakage of the rings, large clearance, and excessive leakage. To remedy this, practically all builders started in to provide from 1/64 to 1/32-in. clearance on the sides of the rings, allowing the rings to float axially by such an amount, the theory being that a slight amount of pressure on one side of the ring would hold it against the opposite side of the groove. As a matter of fact it is not possible to keep a ring over to one side of a groove in a steam turbine under operation, especially where the difference in pressure between one side of the ring and the other is small.

Leakage which takes place through a usual form of carbon packing gland consists of leakage around the ring and leakage between the joints of the segments. It has been found by experiment that the first mentioned leakage amounts to practically nothing. The fact that the leak-

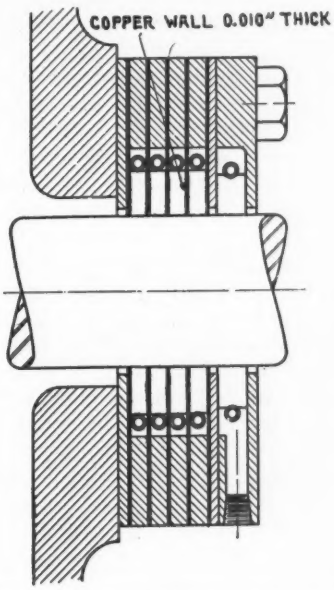


FIG. 4. RINGS WITH BUTT JOINTS AND AN UNUSUALLY HIGH CROSS SECTION ARE ALSO USED

age around the ring will be the heaviest is evidenced in the development of the labyrinth gland, as if this were not so, one ring with a long fit on the shaft would be all that is necessary.

Leakage between the joints has been given considerable study to eliminate the leakage which takes place around the ring. One turbine gland has been developed, illustrated in Fig. 4, which consists of a series of rings with butt joints, but of a narrow, unusually high cross section. These rings are held together with the usual spring and prevented from turning by mean of stops in the casing. The partition walls between the rings consist of thin copper walls which are flexible and reach down to the shaft. The steam pressure will hold the walls close to the ring surface, thus preventing leakage along the side of the ring and through the joints of the ring.

This gland is often provided with a non-corrosive sleeve on the shaft which eliminates pitting of the shaft under the carbon rings, which is especially liable to take place with turbines having intermittent operation and where the oxygen and moisture alternately act on the polished shaft surface under the rings.

Recent European Hydraulic Machinery Design

Propeller and High Head Reaction Runners, and Improved Nozzles, Are Features of Latest Practice. By F. Johnstone-Taylor

EUROPEAN ENGINEERS, and British engineers in particular, willingly admit the part America has played in the development of the modern hydraulic turbine; nevertheless, progress in Europe during recent years has been considerable. The world-wide increase in the cost of fuel has brought with it a remarkable development of water power, principally in Northern Europe and in the British Colonies. So far as the Pelton and Francis types are concerned, no great advance has taken place which can be said to be a decided improvement upon accepted American practice.

It is interesting to note that, while the vertical shaft turbine appears to be almost standard practice in America for the development of large powers on falls of about 50 ft., European practice largely favors the twin horizontal type. Propellor type runners are attracting a good deal of attention, the designs of Kaplan and Lawaczeck having been worked out for large powers. Concomitant with these developments, some new types of valves and sluices have come into being. In the following notes it is proposed to review the salient features of machinery and equipment of note:

European engineers have not been slow to recognize the merits of the propellor type runner for certain conditions of head, speed and output. Following on the successful installation of one or two small plants with Kaplan runners and the testing of some small Lawaczeck runners at the Finshyttan (Sweden) testing station, both types figure in a large plant at Lilla Edet. The layout of these units is depicted in Fig. 1; although this shows a Kaplan runner, the arrangement of the unit with the Lawaczeck runner is essentially the same. Designed to develop 10,000 hp. at 62.5 r.p.m. under a somewhat variable head averaging 21 ft., the Kaplan turbine has a runner diameter of 5.8 m. and the Lawaczeck of 6 m.

Propellor type runners of helical shape figure in two new units at Wynau, Switzerland, developing 2700 hp. under a variable head ranging from about 8 to 17 ft. As seen from the arrangement in Fig. 2, the setting is that usually associated with Francis turbines, while the guides are somewhat numerous, 30 all told. The runners, which have four blades and a maximum diameter of 11 ft. 4 in., are much like a ship's propellor in shape, the blades being rather long and backed off so as to give the largest diameter at the extreme tip. The supporting bearing, mounted above the generator, supports runner, rotor and shaft and also takes the thrust load totalling over 80 T. In common with other turbines having propellor type runners, these units have a high speed on a comparatively low fall, a high efficiency at normal load—a maximum of 89 per cent was reached during official tests—and a much better efficiency is maintained at reduced power consequent upon reduced head than would be possible with a Francis turbine under similar conditions.

High Head Reaction Turbines for Colonial Developments

It is only recently that the building of high head Francis turbines has been taken seriously in Britain mostly because of colonial water power developments. Two concerns are equipped for the building of such units: The English Electric Co., whose designs follow closely American practice, and Armstrong Whitworths, who are allied with Jensen & Dahl of Kristiania and have naturally followed Scandinavian practice. The machines for the Herlandsfossen plant in Norway were built by Armstrong Whitworths. There are four units here, each of 3500 hp., operating on a head of 420 ft. at a speed of 600 r.p.m.

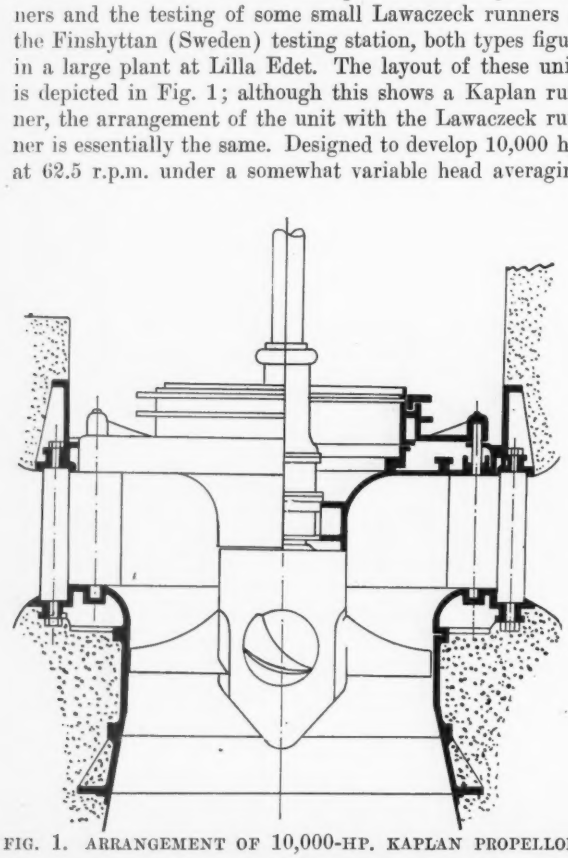


FIG. 1. ARRANGEMENT OF 10,000-HP. KAPLAN PROPELLOR TYPE RUNNER AT LILLA EDET, SWEDEN

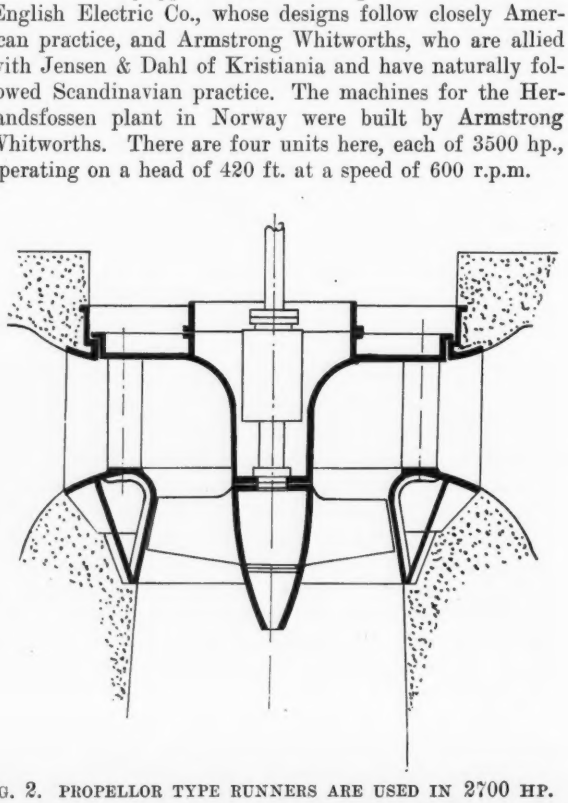


FIG. 2. PROPELLOR TYPE RUNNERS ARE USED IN 2700 HP. TURBINES AT WYNAU, SWITZERLAND

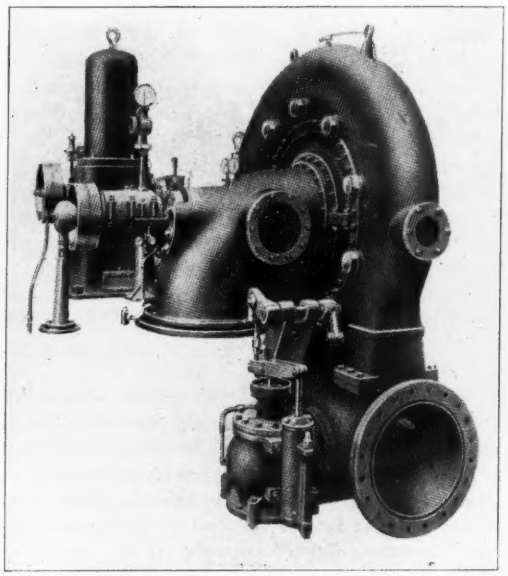


FIG. 3. TURBINES AT HERLANDSFOSSEN HAVE OVERHUNG RUNNERS

FIG. 4. REACTION TURBINES FOR 600 FT. HEAD IN BRAZIL, DEVELOPING 25,000 HP., USE BRONZE RUNNER

One of these units is illustrated in Fig. 3. The runners are overhung, the bearing seen beyond the suction elbow being a thrust bearing for dealing only with unbalanced hydraulic thrust. The runner is of cast steel with plate steel buckets cast into hub and rim. These buckets, which are thinned down at the inlet and outlet edges, are forged on a cast-iron die and then ground smooth; this method, it is claimed, insures a bucket smooth of surface, homogeneous, free from blowholes, correct to dimensions and having good resistance to corrosion and erosion. The casings are of cast iron, cast in one piece. They are reinforced with stays at every second guide vane, the stays being of stream line section in the direction of flow. Through each of them is passed a steel stay bolt fitted with cap nuts and designed to withstand the full pressure of the water so that the stays in the casting merely serve as fixed guides. The governor, a standard type of the Myrens Verksted, operates in conjunction with a pressure-relief bypass valve.

For the Humberarm development, Newfoundland, Armstrong Whitworths have constructed seven spiral-cased Francis turbines each developing 14,000 hp. at 375 r.p.m. The head is moderate 250 ft. These units again have cast steel hub and rim with cast-in buckets, the runners being 57 in. in diameter. The casings, however, are of cast steel in three sections and in view of the large amount of water passing through each turbine they are of massive dimensions, weighing 25 T. apiece. These turbines are not overhung; the shaft is carried in two bearings, one mounted on the discharge and being combined with a Michell thrust bearing, the other being a pedestal bearing with spherical seated liner. Flywheels were deemed necessary for these units because the water passes through 4000 ft. of pipe and the location is unsuited to a surge tank. These wheels, located between the connecting flanges of generator and turbine, are built up of cast steel hub and rim connected by boiler plate disks.

Turning to the English Electric Co.'s turbines built for the Sorocaba scheme, Brazil, American practice is much in evidence. Developing 25,000 hp. on a 600-ft. head, cast steel casings were called for, the average thickness of the metal being 1¾ in. The general construction incorporates overhung bronze runners as illustrated in Fig. 4, electro-hydraulically operated control valves, and a governor-operated relief valve of more or less orthodox form.

In the Pelton field, the principal feature of the English Electric Co.'s design is the successful adoption of the spear-cum-deflector governing system which, although somewhat complicated, is no doubt extremely effective. The English Electric Co., in their 15,000-hp. units for the Tata Power Company, Bombay, have adopted the Seewar system which, as most readers are aware, diffuses the jet as the first stage of speed reduction. This diffusion renders the jet temporarily inactive in the same way as the deflector diverts it from the wheel; in the meantime, the spear is adjusted to a new position demanded by the governor. The virtue of the system lies in the fact that the destruction of the jet does not require important forces and can therefore be effected rapidly, thus allowing for a small increase of speed in the case of a sudden drop in load. The second stage of the speed regulation is effected by the spear, which is controlled by the blades. Its closing motion is retarded sufficiently to ensure freedom from shock in the pipe line.

Control of Jet in Pelton Turbines

This arrangement is shown in Fig. 5, the diffuser blades being shown at a in their normal full load position: when they are pushed forward into the water stream, the issuing jet of water is diffused and rendered inactive. A whirling motion is imparted to the water by the blades and this, through rollers b, is taken by the spear c and transmitted by keys to the nozzle through the fixed guide blades d. These provide a bearing for the spear and, by rectifying the flow through the nozzle, improve the form and efficiency of the normal cylindrical jet. When, in conjunction with the governor, shaft e turns, it also moves the internal valve rod in the distributing valve. This is

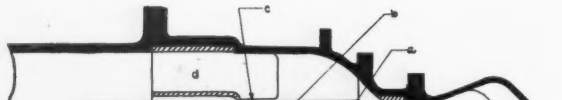


FIG. 5. GOVERNING SYSTEM USED ON ENGLISH ELECTRIC CO.'S PELTON TYPE TURBINES

FIG. 7. BALANCED VALVE OF THIS TYPE IS OFTEN USED ON PIPE LINES

the means by which the guide blades control the position of the spear.

As the latter moves forward, it also moves the outer sleeve of the distributing valve until both the inner valve rod and the outer valve sleeve occupy their neutral positions again. If the drop in load be only partial, the blades are so controlled by the governor that, as soon as the spear has reached the amount of closing necessary for the new load, they remain steady and keep the spear in its new position of equilibrium. There are no cams, as usually associated with this system, and, as the strokes of the regulating rod and sleeve are directly proportional to the stroke of the blades and of the spear, the whole control is simple.

New Types of Valves Are Developed

Until comparatively recently, sluice valves were used upon pipe lines rather because of the absence of anything better than of any particular virtues possessed by this type. The Johnson plunger valve is regarded quite favorably here, but it is costly. Butterfly valves are used to a considerable extent in Northern Italy, one made by Tubi-Togni Co. of Brescia being shown in Fig. 6. For moderate pressures they are considered satisfactory.

One of the newcomers in the valve field is virtually an adaptation of this type in the form of the rotating plug valve. One design by Escher Wyss consists of a spherical casing containing the two bearings, upon which the journals of the valve are supported. The valve seat is annular and is fixed to the disc. When the valve is closed this disc is pressed onto the fixed seat of the casing. The water can only reach the rear face of the disc by an intensive throttling on the circumference thereof. It is, however, connected to the downstream side of the main and when this valve is opened the whole pressure on the rear side of the disc is released. The valve can then be turned by gearing through a quarter turn with but little resistance.

Another new type of valve, the Lundgren-Boyd, has the rotating plug as its principal feature. This plug turns on journals in the covers but, before turning, the valve is lifted slightly by pressure. After being turned, this pressure is relieved and the plug forced home. In this particular valve the turning is effected by rams in cylinders engaging with a rack and pinion, an arrangement well suited to remote control.

Figure 7 shows a balanced valve of the English Electric Co., somewhat resembling the Johnson valve. Electrically controlled and hydraulically operated, it consists of a sliding cylinder a designed as a differential piston and sliding on a bronze lined inner body b. The latter is so connected to the outer body that by removing the dismantling ring c, which is in halves, and turning the cen-

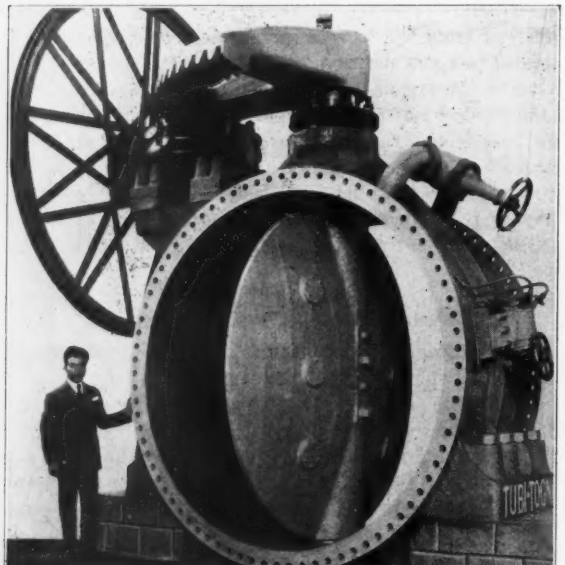


FIG. 6. BUTTERFLY VALVES LIKE THIS ARE OFTEN USED FOR MODERATE PRESSURES IN NORTHERN ITALY

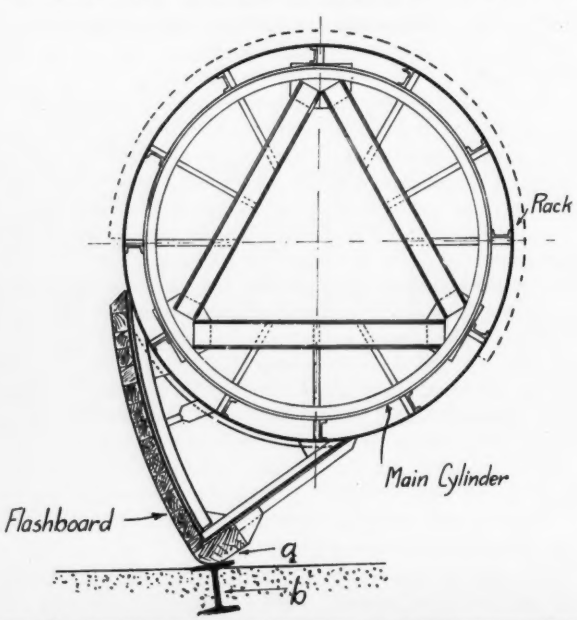


FIG. 8. ROLLING SLUICE GATE USED AT FORSHUVUDFORSEN

tral dismantling bolt d, the length of the valve can be so shortened as to allow dismantling without any special expansion joint, while inspection and removal of the hydraulic leathers is an easy matter. Ribs e—e′ serve to stiffen both outer casing and inner body. An important feature of this valve is the traveling control valve (not shown) which, like the regulating valve of the spear, is in the form of a screw. This screw travels with the valve piston in such a way that the more the piston closes, the more threads of the screw have to be traveled by the water coming to the closing chamber. Thus the rate of travel of the piston decreases little by little and is slowest when approaching the end of the stroke, thus preventing water hammer in the pipe.

Roller Sluice Gates Are Used in Open Channels

In connection with the control of water in open channels, the free roller sluice gate as seen in the Stoney and Ashford types satisfies practically every requirement and has yet to be improved upon in any marked degree, although ice troubles, when this type of gate is used in severe climates, are of no small moment. Ice has always figured largely in the troubles which beset water power development in Northern Europe. The various means taken to combat the evil formed the subject of two papers at the World Power Conference, one by Fred Samsioe and the other by Arvid Ruths, dated July 4, 1924. Various means of heating the gates were discussed and the information is commended to those interested in the problem.

Rolling gates have been installed at some of the large Scandinavian plants; those at Fordshuvudforsen are worthy of mention as being a good example of prevalent practice. The general principle of this type of gate is, of course, well understood by engineers and need not be gone into beyond stating that the gate itself is segmental in form and its motion rotational about a pivot. One of the gates referred to is shown in Fig. 8. It will be seen that it is mainly constructed of steel sections and plating; the water seal is in the form of timber toe a bearing on I-beam b set in the floor of the culvert.

Fuel Pumps for Solid Injection Engines

Method of Fuel Injection Determines Success of Atomization. By H. F. Birnie

WITH SOLID INJECTION, no matter how effective the design of spray nozzle, atomization cannot be satisfactory unless the fuel is given sufficient velocity. This is dependent on the nozzle pressure, which should always be kept above a certain limit during the injection period. Accordingly, as the plunger starts to lift, the pressure at the nozzle must increase suddenly and then drop just as rapidly when the bypass valve opens, showing that the pump is at the end of its effective stroke. There must be a uniform and well atomized spray during the whole period of fuel injection and it is therefore important that careful consideration be given the types of pumps used for airless injection.

Pumps for Solid Injection an Important Consideration

Fuel pumps of true Diesel engines using air injection only measure the quantity of fuel required for a given load, since the timing of the injection is done by a cam controlled fuel needle and atomization is effected by compressed air.

With airless injection engines, fuel pumps have more important functions and may be divided into three groups in which:

1. The pump plunger measures, builds up the pressure and times the injection.
2. The pump plunger builds up pressure and times injection, while the measuring of the fuel charge is effected with an auxiliary pump.
3. The pump plunger only builds up pressure. Measuring and timing the charge is effected by a cam-driven needle valve controlled by the governor or by hand.

Characteristics of Pumps of the First Group

Pumps in this classification are generally cam-driven and used with either lightly or heavily loaded automatic spray valves. The latter are sometimes called differential valves.

With either arrangement there is a separate plunger serving each power cylinder. In contrast with these a third arrangement is sometimes used, which consists of a single plunger for all power cylinders with a mechanically operated distributor valve and which switches alternately from one cylinder to the other. This latter arrangement is used with either lightly loaded or differential spray valves.

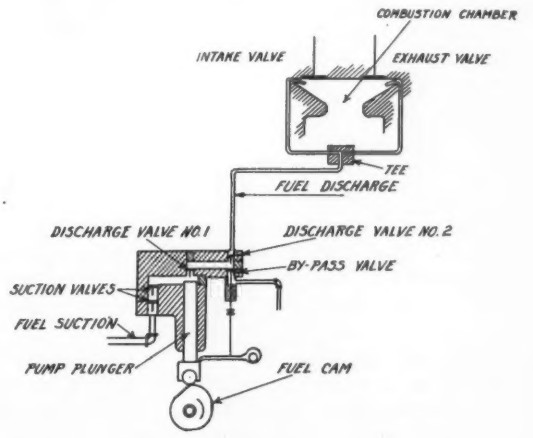


FIG. 1. GENERAL ARRANGEMENT OF FUEL PUMPS, SPRAY NOZZLE AND COMBUSTION CHAMBER

A general ensemble of the fuel pump, spray nozzle and combustion chamber, as used under the preceding conditions, is shown in Fig. 1, while a more detailed view of the pump is shown in Fig. 2. This pump is of the cam-operated type which generally has a sluggish plunger motion at the beginning of the fuel injection and for this reason is undesirable for solid injection engines, except in connection with combustion chambers employing violent turbulence.

The pump has two suction and two discharge valves, a by-pass valve, and as previously mentioned, a cam-driven plunger. As the plunger recedes and goes downward from the top of the cam nose it opens the suction valves, admits

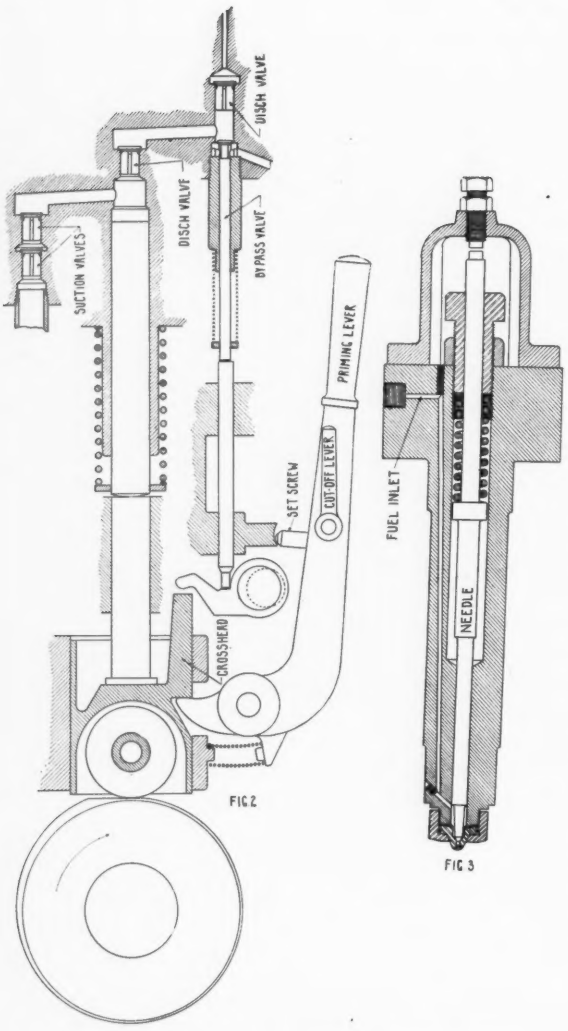


FIG. 2. DETAILS OF A CAM OPERATED FUEL PUMP
FIG. 3. DETAILS OF HEAVY LOADED SPRING CHECK VALVE—ALSO CALLED DIFFERENTIAL VALVE

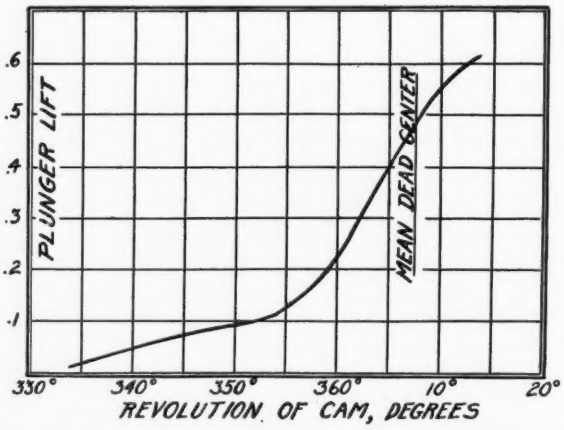


FIG. 4. PROFILE OF FUEL CAM USED WITH A DIFFERENTIAL VALVE

the charge and delivers it to the nozzle through the discharge valves. At a certain point in the upward travel of the plunger crosshead, the by-pass valve lifts and allows the fuel to be returned to the tank instead of being delivered to the nozzle. The governor controls the amount of by-passed oil through the medium of a finger mounted on an eccentric so that the by-pass valve opens earlier with a light load and later when the load is heavy.

The diagram also shows the priming lever and a small cut-off lever mounted on it which keeps the roller clear of the cam. Provision is also made to vary the clearance between roller and cam by adjusting a set-screw fixed on the priming lever.

Referring again to Fig. 1, it may be seen that the general arrangement permits several variations. When using the first discharge valve only, the fuel pressure is reduced to that of the atmosphere, when the by-pass valve opens. In consequence, pressure in this line must equal that on the nozzle check valve before the injection can proceed. This means that as fuel oil is somewhat compressible, the "lead" of the injection must be increased. This arrangement offers the advantage of shortening the time of coarse spraying at the end of the injection period and allowing the fuel to expand in the direction of the open by-pass valve. It has been found advisable in this case to provide two check valves in the spray nozzle, instead of one, in order to obtain an effective seal against the gases under pressure in the combustion chamber.

Another arrangement may be made by removing the second discharge valve and placing it in the tee, or, instead of using a spray nozzle with lightly loaded check valve, the fuel pump of the first group may be used with the so-called differential valve. A differential valve consists of a needle held down on its seat by a heavy spring, as illustrated in Fig. 3. The fuel oil pressure acts on the small ring surface at the end of the needle, so that the opening and closing pressures can be kept high. The corresponding spray velocities will insure good atomization of the fuel oil during the whole injection period.

Differential Valves Have Important Functions

Differential valves relieve the fuel pumps of the necessity of building up the pressure in the delivery line too quickly. Fuel oil is compressible and, depending on the volume of fuel in the discharge line and the opening pressure of the differential valve, the pump plunger will make an appreciable stroke before it starts delivering to the combustion chamber. In other words, the first part of the plunger stroke is used to take up the compression volume of the oil and compress the gases in the fuel and the second in making the actual delivery. This sequence of operations is shown in Fig. 4, which represents the profile of a fuel cam used on an injection system with differential valves.

In practice, the opening pressure of a differential valve is between 3500 and 4000 lb. per sq. in., and the closing pressure from 3000 to 3500 lb. per sq. in., which permits a relatively high spray velocity at all times. During the period of injection the pressure in the discharge line is generally between 5000 and 6000 lb. per sq. in. For such high pressures turbulence is not essential, provided that the distribution of the spray conforms to the shape of the combustion chamber. The principle of the fuel pump, used in conjunction with a differential valve, often is as shown in Fig. 2. In this case it seems best to eliminate the second discharge valve so that atmospheric pressure may be permitted in the discharge line after each power stroke. The

compressibility of the fuel oil is thus utilized in insuring a slow rise of the fuel cam profile. Later on, the advantage of retaining this valve will be shown.

It is apparent that if the second discharge valve were retained a smooth drive of the fuel pump could be obtained with the aid of an auxiliary plunger which would be pushed back during the beginning of the stroke. The spring acting on this plunger should be of such strength that when the auxiliary plunger comes to its stop position, the pressure on the fuel will be close to the opening pressure of the differential valve. The principle of this operation is shown in Fig. 5.

Distributors Insure Equal Charge to All Cylinders

With a single fuel pump plunger for all the cylinders mechanical distributors are sometimes used to switch the combustible from one spray valve to the other. The regulation of the amount of fuel corresponding to the load, is usually done with a by-pass valve under governor control. Figure 6 shows the general arrangement of these distributors with the fuel pump having the customary suction, discharge and by-pass valves; the pump plunger driven by a multi-lobe cam and a single pipe connecting the pump to the mechanically operated distributors. This system has the advantage of always distributing an equal load to each cylinder. With this arrangement, either lightly loaded automatic spray nozzles or differential valves may be used, since the only difference will be that the former will require a combustion chamber giving induced turbulence.

Figure 7 shows the construction of a distributor used in conjunction with a differential valve. The cam operated stem is pushed downward and holds open the small valve *a* to allow the fuel pump to discharge into the line to the spray nozzle. As the injection period ends, the stem recedes

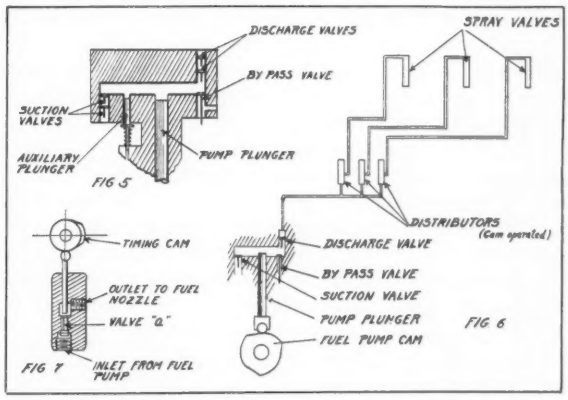


FIG. 5. VALVE ARRANGEMENT IN FUEL PUMP

FIG. 6. GENERAL ARRANGEMENT OF MECHANICAL DISTRIBUTORS FOR SPRAY VALVES

FIG. 7. DISTRIBUTOR USED IN CONJUNCTION WITH A DIFFERENTIAL VALVE

until the valve seats and then continues its travel backward in order to relieve the pressure in the spray valve line and so prevent leakage into the combustion chambers.

When used with a differential valve this system apparently offers several difficulties, but in actual practice, these have been overcome most satisfactorily. Under certain conditions, especially where there is an uneven number of cylinders, the multi-lobe is difficult to design so that a good volumetric efficiency of the fuel pump may be obtained. The stroke of the pump plunger must be kept short so as to reduce the height of the cam nose, but at the same time the diameter of the plunger must be kept

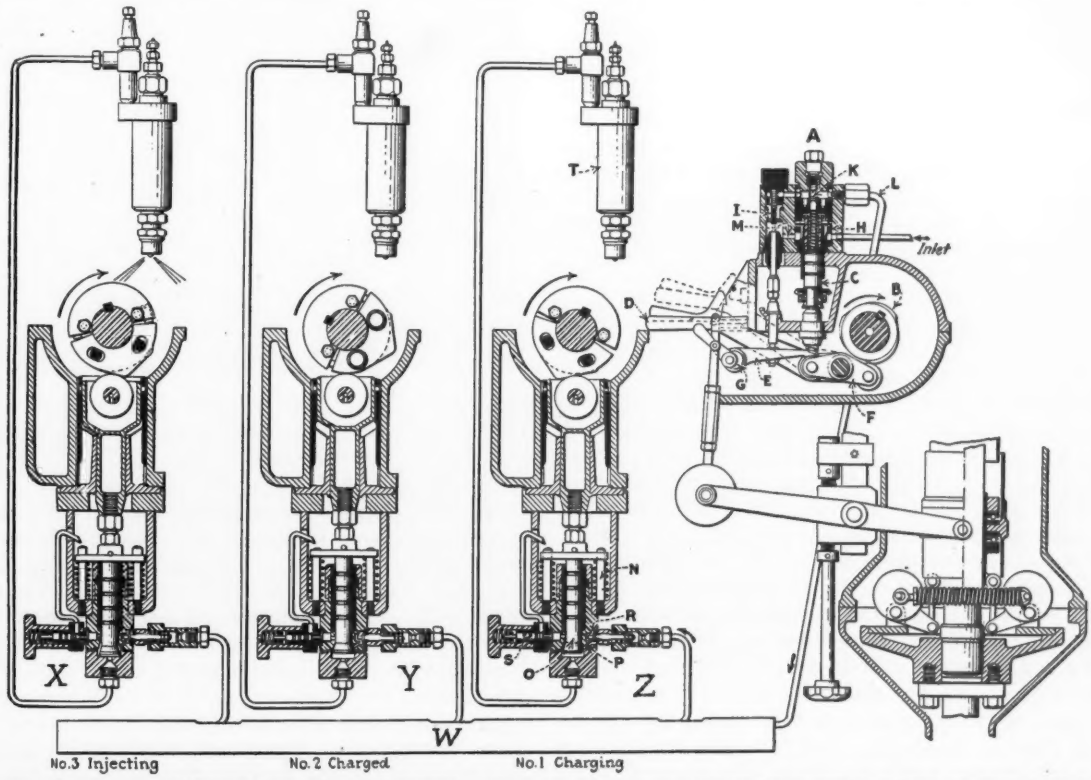


FIG. 8. SINGLE MEASURING PUMP WITH THREE CAM-DRIVEN DELIVERY PUMPS ILLUSTRATES THE SECOND GROUP

small in order to prevent the pressure from building up too suddenly and thus causing unwelcome vibrations. The opening of the differential valve will accordingly be slowed down unless the area at the end of the fuel needle (Fig. 3) is kept small. A slow opening of the needle will cause a throttling loss at the seat, considerably reduce the spray velocity and eventually require induced turbulence to obtain good fuel consumption.

For these reasons the second discharge valve of the fuel pump is retained in order to permit a high pressure in the discharge line and reduce the travel of the pump plunger. Induced turbulence has also been provided in

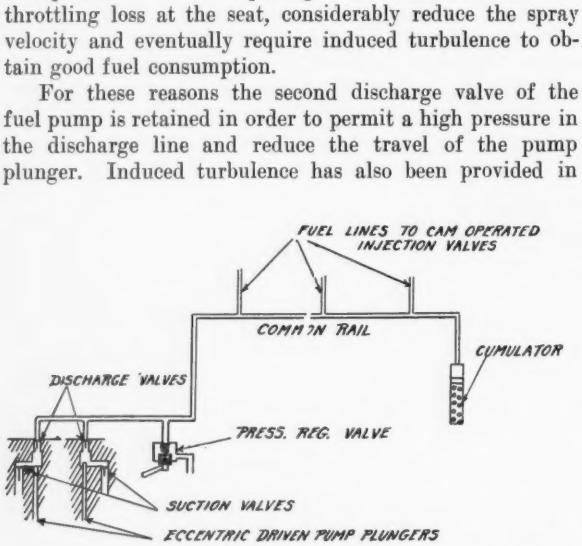


FIG. 9. GENERAL ARRANGEMENT OF THE COMMON RAIL SYSTEM

certain models using the single plunger system with a differential valve, by fitting a shield in the air intake valve and so causing a rotary motion of the air charge.

Characteristics of the Second Group

Injection systems of this group have two fuel pumps—one measuring the fuel required by the engine and the other for building up the fuel pressure and timing the injection. The opening of the fuel valve is sometimes mechanically controlled, but the closing automatic. This feature was made necessary in order to permit the same lead at all loads. The practical advantages of the distinct separation of the functions of the fuel pump lies in the fact separation of the functions of the fuel pump lie in the fact that the measuring pump can be conveniently located near the governor and also in some cases the fuel can be measured more accurately by always being under low pressure. The delivery pump may be either cam driven, or pushed by a heavy spring under tension or finally actuated by the compressed air in the combustion chamber.

Figure 8 illustrates a pump of this second group. It shows a single measuring pump *A* using low pressure, with the usual by-pass system connected to the governor. In order to serve all the cylinders, the pump is driven by a multi-lobe cam, and discharges in a common header *W*. The delivery pumps *X, Y, Z*—one for each firing cylinder —have their suction line connected to the manifold, *W*, while the discharge leads to the differential spray valve, *T*, located in the center of the cylinder head. These three pumps are cam driven. The lower end of the plunger is conical and is seating when the pump roller is off the nose of the driving cam, thus preventing, while in this position, the injection of any fuel by pump *A*. During the delivery stroke pump *A* is also prevented from delivering fuel to the other pumps on account of the high pressure acting on the suction valve *R*. In this way fuel may be introduced to *X, Y* and *Z* only when the plunger has finished its delivery stroke and is coming back toward its seat.

Since the stroke of the delivery plunger *O* is constant, while the amount of fuel going through the spray nozzle varies with the load, a flexible element must be introduced in the delivery line, to make up the difference of volume between maximum and minimum loads. This device, may take the form of a spring loaded plunger and, as a result, the lead of the fuel injection will be greatest with heavy loads and smallest with light loads.

High delivery pressures are maintained by the use of a differential valve. The combustion chamber should be of standard Diesel design—slightly concave and with no provision for directing or increasing the turbulence of the intake air. The measuring pump *A* being of the single plunger type, insures accurate measuring and even distribution to each cylinder.

Characteristics of the Third Group

As outlined in the beginning, the fuel pumps in this group have only one function, which is to maintain pressure in a main, or "common rail." This may vary according to the load on the engine. The timing of the injection

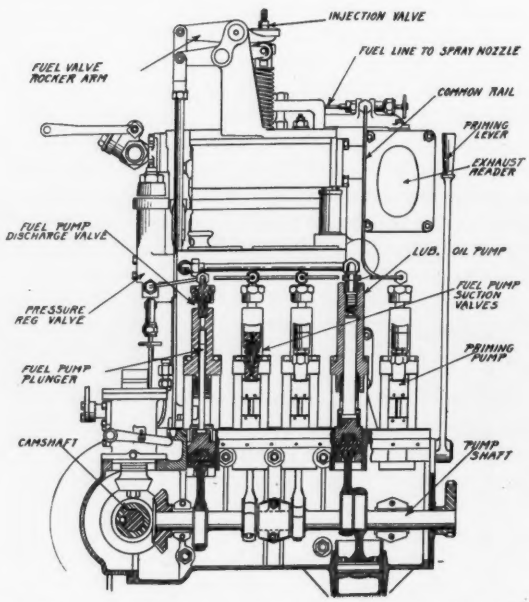


FIG. 10. DETAILS OF FUEL PUMP OF THE THIRD GROUP

and the measuring of the amount of fuel required by the load are done by a cam-controlled fuel valve under governor control. The amount of fuel is varied by diminishing or increasing the lift of the valve needle.

Figure 9 shows a schematic layout of the common rail system which comprises two or more eccentric driven fuel pump plungers, a pressure regulating valve, a main header with leads to each fuel valve and a cumulator. The latter is generally not found on medium and larger size engines since the piping allows sufficient volume to insure a practically constant spray velocity during each period of fuel injection.

Various designs of the common rail system are differentiated by mechanical features and refinements rather than by working principles. Smaller engines, for instance, vary the lift of the fuel needle by varying the distance of the

roller of the rocker arm from the fuel cam nose causing thereby the lead of the injection to be smaller with light loads than with heavy loads. On larger units this drawback is remedied so that the lead of the fuel injection also increases with a reduction of the fuel needle lift.

Figure 10 shows a fuel pump with three eccentric-driven plungers, and with individual suction lines, discharging into a common header. A pressure regulating valve is shown at the left, and a hand priming plunger at the right. Each plunger has two suction and two discharge valves. A fifth plunger of more liberal size is used for the lubricating system and is driven by the same eccentric shaft.

Primarily, induced turbulence is not required on engines of the common rail system as the spray velocity may be increased or decreased at will. The oil pressure in the common rail is generally held at approximately 4000 lb. per sq. in., but may be increased when using heavy oils. Records show that under certain conditions, pressure as high as 11,000 lb. per sq. in. has been maintained.

Rotted Piles Necessitate Rebuilding of Plant Foundation

RECENTLY THE entire supporting structure of Station L of the Portland Electric Power Co. was removed and replaced without any interruption of service. The problem which necessitated the change was the rotting of the wooden piles on which the building rested.

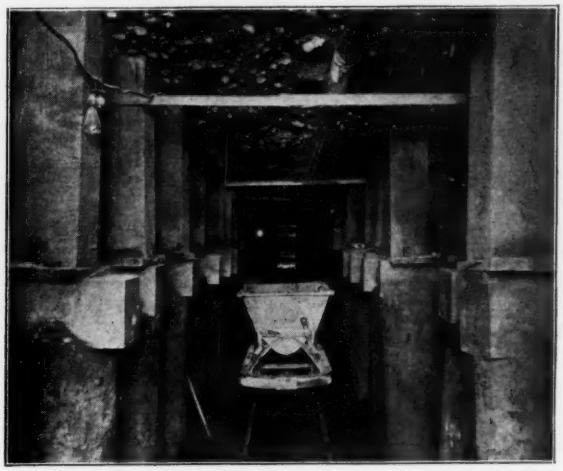


FIG. 1. TUNNELS WERE CONSTRUCTED TO REMOVE DIRT FROM AROUND PILING

When the power station was built, about 1909, it was located near the river to facilitate transportation of hog fuel. The ground was unstable, so piles from 50 to 100 ft. long were sunk for a base for the building, which was 135 ft. wide and 165 ft. long. A cement mat, about 3 ft. thick, topped the piles and served as a base for the building. Discovery that the piles had decomposed and that the building with its heavy machinery was in danger of settling to such an extent that it would have to be rebuilt, came about a year ago when an additional unit was being installed.

Work was started in July and was continued as fast as the lowering water level would allow. A shaft about 35 ft. deep was sunk on one side of the building and a system of tunnels was completed. Although the excavation was by sections, more than 1800 cu. yd. of earth was removed to allow workmen to saw off the old piling.

With the old piles cut at the lowest water level and tested for 15 T., they were used as supports for pre-cast concrete beams. One of the reinforced beams was placed across two piles and a larger beam, about 3 ft. thick, crossed the small beams for the support of the column. The new supports were 11 ft. 6 in. long of reinforced concrete and were secured by means of steel wedges cemented in place

FIG. 2. OLD CONCRETE MAT NOW RESTS ON PRECAST CONCRETE STRUTS AND BEAMS

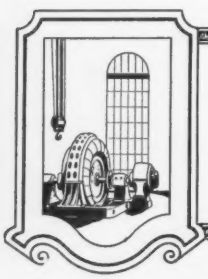
at the top. When the reconstruction of the piling was completed, it was necessary to return the excavated earth and to tamp it into place. During a greater part of the time the work was carried on by three shifts of workmen.

The general plan was by O. B. Coldwell, second vice-president and general manager in charge of power for the electric company. He was assisted by Charles P. Osborne, general superintendent of power and lights.

Features of Airless Injection Engines

IN THE ARTICLE under this title that appeared in the June 15 issue, a typographical error was made on page 643, in the data for insertion in the formula for finding the oil pressure. The fifteenth line from the bottom of the right hand column should read: "then by assuming a velocity of 500 ft. per sec." instead of 1000 ft. per sec.

THE LOS ANGELES GAS & ELECTRIC CORP., Los Angeles, Calif., is selling a new bond issue of $2,952,000, a portion of the fund to be used for extensions and improvements in plants and system, as well as general financing.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Electrical Features of the Somerset Station

NEW BASE LOAD STATION FOR THREE NEW ENGLAND UTILITIES HAS INSTALLED THE MOST MODERN TYPE OF EQUIPMENT

AMONG THE MORE important generating stations recently completed, the Somerset Station of the Montaup Electric Co. occupies the unique distinction of being the first base load station owned and operated under a cooperative plan by several independent utilities. The mechanical features of this station, which was designed and constructed by Stone & Webster, Inc., of Boston, were fully described in the April 1 issue of this publication. In this article will be discussed some of the more important features of the electrical equipment installed at this station.

Since the sole object of the Somerset station is to furnish large blocks of power to each of the companies interested, no local distribution at the generated voltage of 14,000 is planned, all power being sent out at 66,000 v. initially. When justified by the increased demand, the line voltage will be raised to 115,000. For this reason, the electrical bay is of the simplest type. The only 14,000-v. switching provided is that necessary for supplying power to the electrically operated auxiliaries and for generator switching, which affords greater flexibility and a greater degree of generator protection.

As stated in the April 1 issue, the initial installation consists of a 32,000-kw. turbine connected to a 30,000-kw., 14,000-v., three-phase, 60-cycle main generator with a 2000-kw. auxiliary generator and exciter mounted on the same shaft.

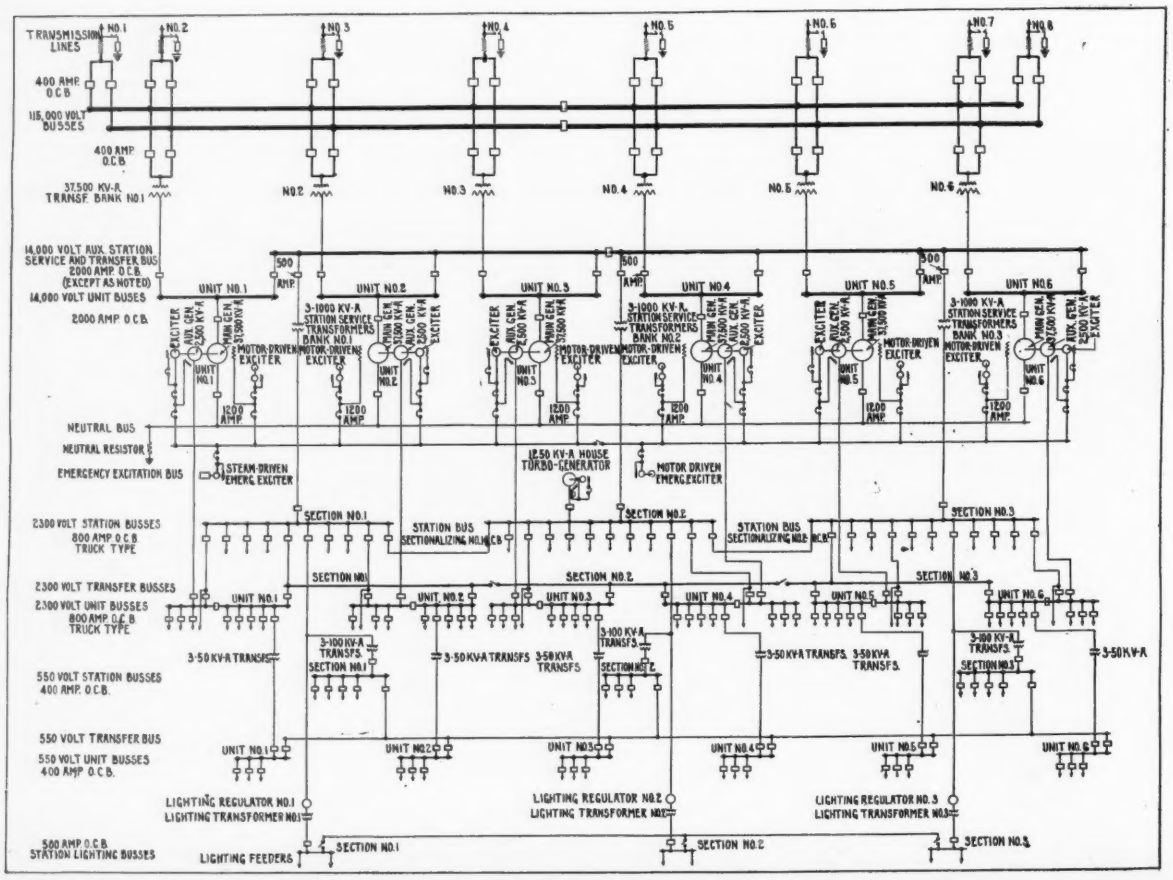


FIG. 1. ONE LINE DIAGRAM OF ULTIMATE ELECTRICAL SYSTEM AT SOMERSET STATION

All auxiliaries for normal operation of the plant are electrically driven, power being derived from the auxiliary generator and from station service transformers connected to 14,000-v. station bus.

General Features

A general one line diagram of the electrical connections is shown on Fig. 1. In general, it will be seen that a unit scheme is followed. Each main generator is connected through a 14,000-v. unit bus to a 37,500-kv.a. bank of step-up transformers. Each transformer bank is connected by means of selector oil circuit breakers to either of the duplicate 66,000/115,000-v. busses; outgoing circuits are similarly connected to the same busses. In the initial installation of a single generating unit, only one of the high tension busses with switching is installed. The 14,000-v. auxiliary station service and transfer bus may be supplied from any generator by connection to its unit bus.

Each auxiliary generator is connected to a 2300-v. unit bus from which feeders are run to control boards in various parts of the station. Only auxiliary equipment directly concerned with the operation of a particular generating unit is supplied from the unit bus, such as exciters, circulating pumps, air cooler pumps, and certain boiler auxiliaries. All other auxiliary equipment and station lighting is supplied from a 2300-v. station bus fed from three groups of 3000-kv.a. banks of outdoor transformers which are connected to the 14,000-v. station bus referred to previously. In the initial installation only two 2000-kv.a. banks in open delta are provided. The 550-v. unit busses are each supplied from the 2300-v. unit busses through 150-kv.a. banks of transformers; the 550-v. station busses are each similarly supplied from the 2300-v. station bus through 300-kv.a. banks of transformers. Station lighting from the 2300-v. station bus will be supplied from three 100-kv.a. single-phase transformers, two of which are installed initially. The 2300-v. unit busses are each divided into two sections and the station busses into three sections,

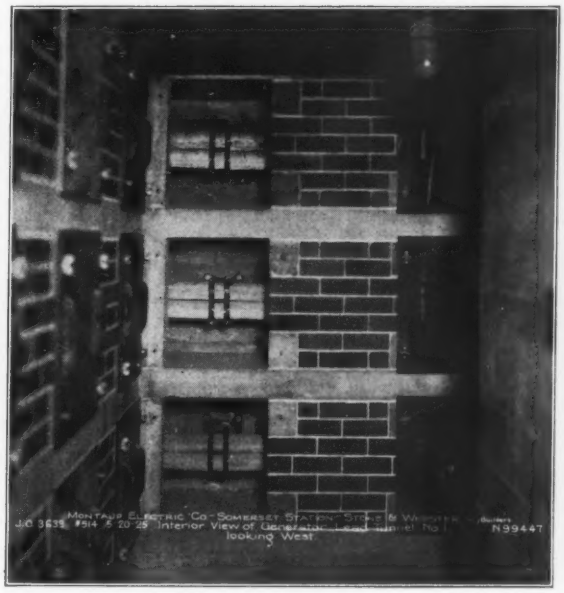


FIG. 2. INTERIOR VIEW OF GENERATOR LEAD TUNNEL NO. 1, LOOKING WEST

a transfer bus permitting various methods of load readjustment in the event of fault in any section. A similar transfer bus is also provided for the 550-v. service. Control circuits and emergency lighting are supplied from a storage battery and charging set.

Excitation for each main generator is supplied normally at 250 v. from a 175-kw., motor-driven set. Excitation for each auxiliary generator is supplied normally from its own 28-kw., direct-connected exciter, also at 250 v. Both main and auxiliary fields can be excited from an auxiliary excitation bus fed by a 200-kw., steam driven set. Automatic

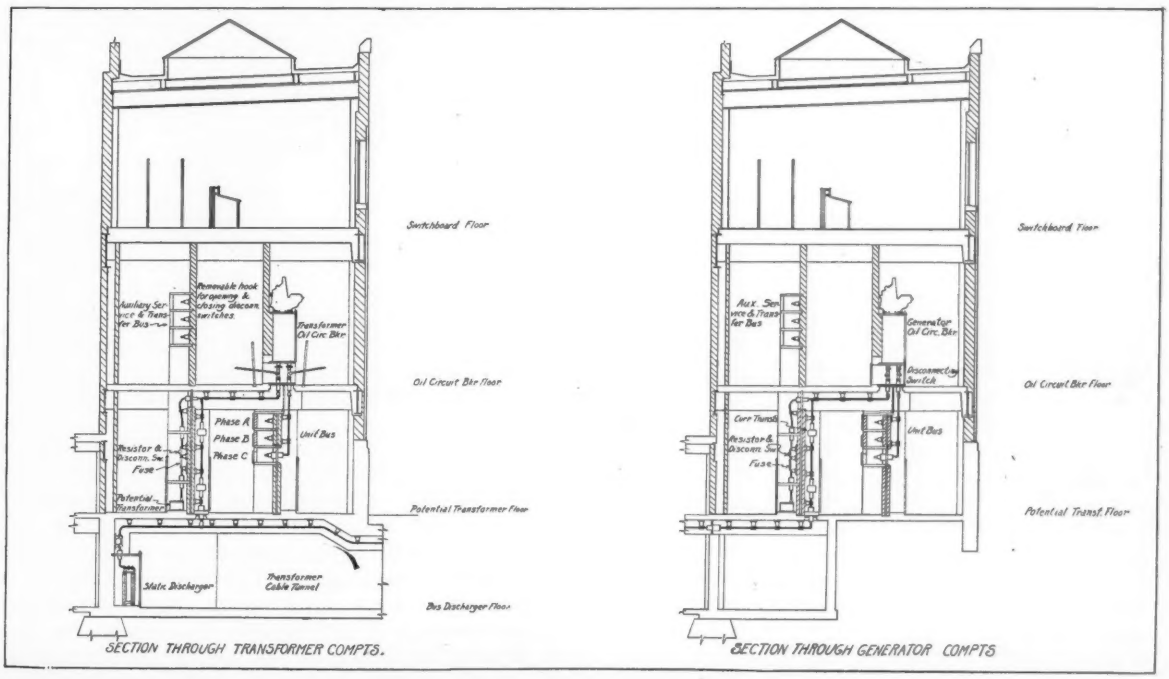


FIG. 3. CROSS SECTIONS OF THE ELECTRICAL BAY

voltage regulation is provided for the auxiliary generators only.

Electrical Structures

Main generator leads are of 15,000-v. insulated cable carried on heavy duty porcelain insulators mounted on a side wall of a concrete tunnel. The tunnel is continuous from the generator foundation to the electrical bay and passes under the main floor of the boiler room. The main leads are separated by horizontal precast slabs and protected at the front by a 4-in. repressed red brick wall, openings in front of insulators being covered with transite. A detail of this tunnel is shown in Fig. 2, where it will be seen that the precast slabs are supported in grooves in the

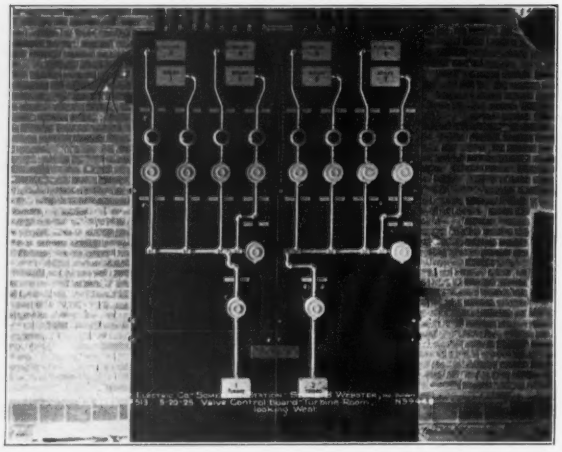


FIG. 4. VALVE CONTROL BOARD—TURBINE ROOM

tunnel side wall and on the enclosing brickwork. The leads for the auxiliary generator and miscellaneous control circuits are run in conduit imbedded in the tunnel walls.

A cross-section of the electrical bay is shown on Fig. 3. All bus, circuit breaker, and potential transformer structures are built of repressed red brick. In order to limit the damage to structures from a short circuit to ground, the use of reinforced concrete is avoided as far as possible. At the few points where it was found necessary to use such construction the reinforcement is not continuous over supports, a clearance of 6-in. being allowed between the ends of steel in adjacent cells. All reinforcement in the concrete floors is welded to the floor steel and grounded.

Load Dispatcher's Room

Load dispatching for the Montaup system is handled at the Somerset Station. The load dispatcher's room is located on the upper floor of the electrical bay adjacent to the main switchboard room. In this room will be installed a mimic board reproducing a one line diagram of the entire system, showing all generators, oil circuit breakers, and disconnecting switches. For the present a simple manually operated board will be used, this being located immediately behind the load dispatcher. Position of breakers and switches will be indicated by various colored pegs or by reflected light from behind the board through the peg holes. Provisions have been made for the installation of an automatic board at a later date.

All switching of outgoing circuits, main and auxiliary generators, station service transformers, and power supply to the truck type station service switchboard is done from the main switchboard. The control switches are located on a circular bench-board on which are mounted mimic busses of stainless steel, copper and brass representing respectively the 66,000/115,000, 14,000 and 2300-v. connections. Indicating instruments are mounted on a vertical board beyond the benchboard facing the operator and relays and meters on another vertical board located beyond the instrument board and back to back with it. Munson slate is used throughout.

No conduit room is provided, all conduits being run in the hollow walls of the electrical bay and carried from there to the main switchboard five layers deep in the floor slab. In the view shown on the contents page of this issue the method of carrying the conduits in floor slab to the switchboard. Flexible conduits in a sill box under the instrument and relay panels permit convenient connection between the two boards.

Auxiliary Switchboard Room

All auxiliary switching is located in what would normally be useless space in the basement of the boiler room.

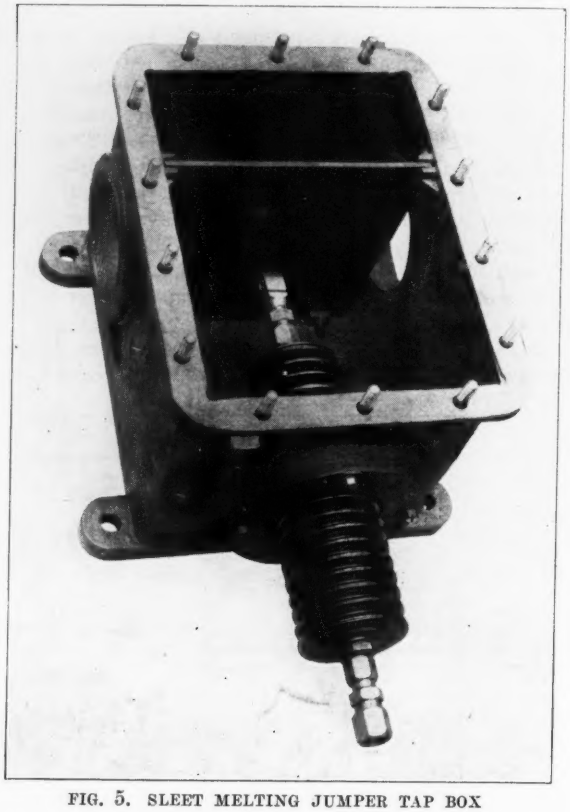


FIG. 5. SLEET MELTING JUMPER TAP BOX

In this room, are contained the 2300 and 550-v. unit and station switchboards, the 550-v. station service transformers, the 115 v. lighting transformers with regulators and the lighting switchboard. The 2300-v. switchboard equipment is of the truck type while the others are of ebony asbestos on pipe frame. Circuits are carried from the truck type board to the step-down transformers and to the control boards in various parts of the station for feeding the larger motors. Circuits from the 550-v. board are run directly to groups of motor control devices located near the respective motors.

Station Service System

An outline of the method of power supply to auxiliaries is given under a general discussion of the one line diagram. All motors over 25 hp. are on 2300-v. service and motors 25 hp. and under with the exception of certain small motors are on 550-v. service. All constant speed motors over 15 hp. are of the double decked squirrel cage type permitting constant speed motors of all sizes to be thrown directly on the line.

Variable speed motors are used for driving the forced and induced draft fans, boiler feed pumps, circulating pumps, and fuel oil pumps. The forced draft and induced draft fan motors are brush shifting commutator type units with series characteristics, the other variable speed motors are of the slip-ring induction type. Those for the fuel oil pumps are totally enclosed even including the collector rings and brush mechanism. The following table gives characteristics of the variable speed motors:

Motor	Speed Range	Power Reduction
40 hp. Forced Draft Fans	64%	93%
150 hp. Induced Draft Fans	69%	95%
300 hp. Boiler Feed Pumps	7½% & 9%	30% & 30%
250 hp. Circulating Pumps	75%	78%
15 & 25 hp. Fuel Oil Pumps	47%	49%

Switchboards for the draft fan motors and future pulverized fuel feeders are located in rooms above the fan floor between coal bunkers, one such room being provided for every four boilers. Actual control of the speed of these motors is at the boiler gage board on the boiler operating floor by means of a Bailey electrical control system, the design of which is such as to permit simple conversion to full automatic control of combustion when desired. Emergency control is also provided at the motors, this being interlocked with the control on the gage boards.

The boiler feed pump switchboard is located near the pumps at the northwest corner of the condenser floor together with a Ruggles-Klingemann control equipment set to maintain a pressure above boiler pressure in the boiler feed line. As this method of control has a limited speed range, four manually set base speeds are provided for each control, the automatic control taking care of the speed reduction from one step to the next lower. Control apparatus

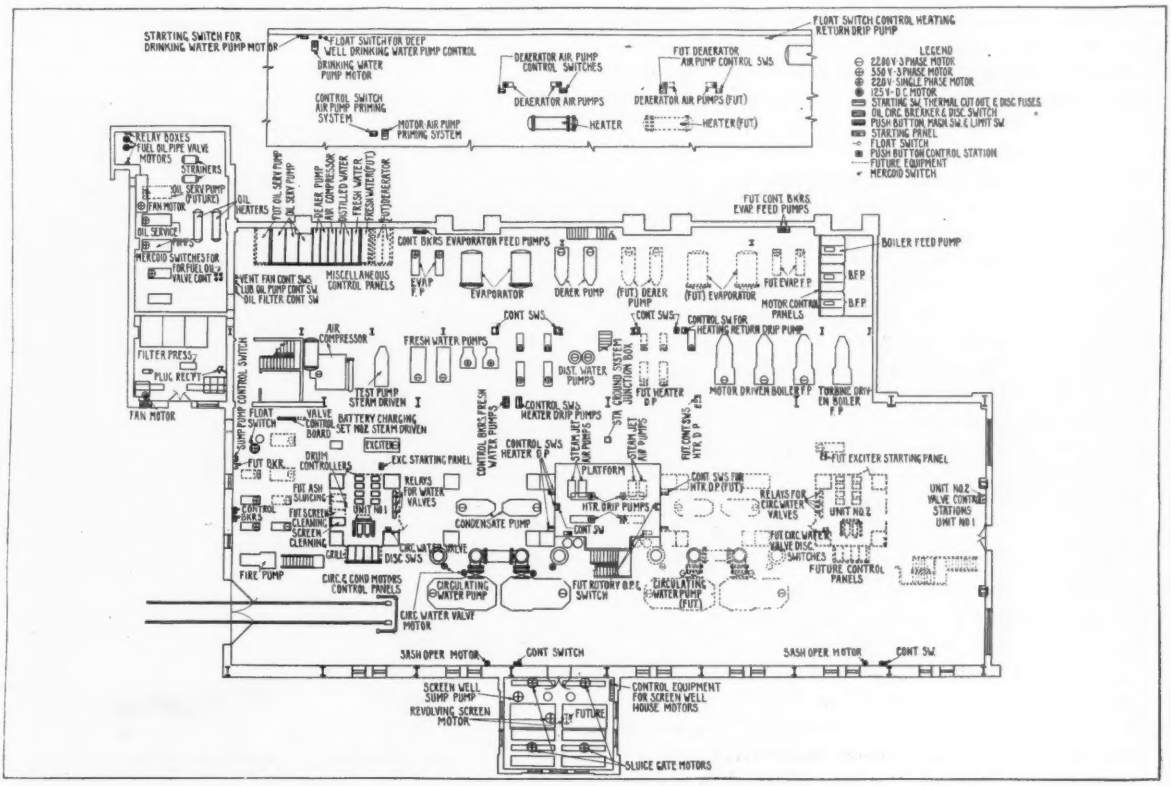


FIG. 6. SWITCHBOARD AND MOTOR LOCATION PLAN

for the circulating and condensate pumps of each unit is located on the condenser floor between columns of the turbine support.

All other large motors and fuel oil pump motors are controlled from a switchboard at the southwest corner of the condenser floor. As in the case of boiler feed pumps, the speed control of the fuel oil pumps is governed by a Ruggles-Klingemann regulator incorporated as a part of the switchboard.

Outdoor Switch Yard

The outdoor switching station is of conventional construction, having a galvanized structural steel frame with horizontal busses and cross connections in tension supported by 132,000-v. strings of strain insulators. The transformer leads are carried from the electrical bay to the yard in tunnels similar in construction to the generator lead tunnels, excepting that the leads are supported from the roof of the tunnel and separated by vertical barriers cast monolithic with the roof. The leads of the first two units terminate in a cable house at the hinge terminal of a

special double throw disconnecting switch, one throw of which is connected to the transformer delta bus and the other throw to a sleet melting bus carried in conduit along the outside columns the full length of the switch yard. Directly opposite each phase of each outgoing circuit is located a special junction box illustrated in Fig. 5, at which a permanent tap is taken off the proper phase of the bus. This tap is carried through a sealed bushing to a connector on the outside of the box. When it is desired to melt sleet from a transmission line the circuit is cut out at each end and short circuited at the far end. At the near end special jumpers are connected from each phase to the proper junction box in the sleet bus and current is supplied to this bus from one of the main generators. This arrangement it is hoped will minimize the great damage from sleet which has occurred in the past in this district.

Miscellaneous Features

A comprehensive system of telephones has been provided. This includes trunk lines with private branch exchange, leased lines between member companies, and a private automatic exchange.

A signal system between the switchboard room and the turbine room includes at the main switchboard a selector type transmitter and indicator with illuminated figures to indicate the source of signals originating in the turbine room. At each turbine gage board a combination transmitter and indicator is provided and a signal lamp mounted above indicates which machine is signalled for by the operator.

The input of all main transformers is totalized on a curve drawing meter by means of Kelvin balance transmitters, one for each bank. A Selsin generator, chain driven from the curve drawing meter, transmits the reading to numerous points in the plant where instruments of proper size indicate, at all times, the total output of the station.

A valve control board shown in Fig. 4 is located near an exit on the condenser floor. This board permits emergency operation of boiler and nonreturn valves, steam header sectionalizing, and turbine lead valves.

Among other electrical features installed in the station are an electric impulse type clock system, a drop type annunciator in the switchboard room, and double-faced illuminated signal type annunciator on the condenser floor for indication of opening of circuit breakers, excessive temperature rise of electrical equipment, high temperature and low pressure of bearing oil and high or low water in storage tanks.

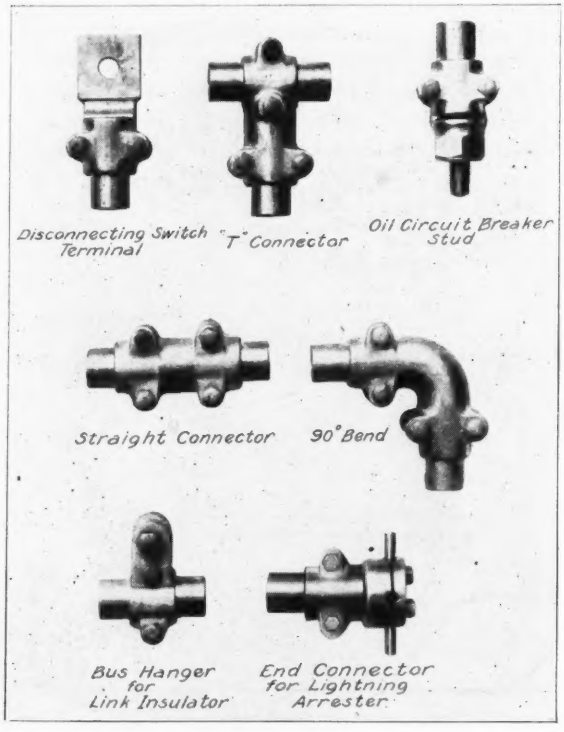
Fittings and Connections for Outdoor Substations

By Wm. T. O'Connell*

IN DETERMINING a conductor to be used as a bus in an outdoor substation—a conductor that will not sag of its own weight with distances between supports of from 10 to 25 ft.—the use of copper tubing or iron pipe has become recognized as the most suitable, thereby reducing the number of insulators necessary to support the conductor properly.

Several large operating companies have used various means of getting a conductor to span a long distance and to reduce the number of insulators and amount of steel work, such as angles secured back-to-back with a spacer between to allow the insertion of a connection. A copper bar, reinforced with small angles along its upper edge, has also been used and other methods have been employed; but none proved so satisfactory and adaptable for all manner of connections and, at the same time, was as cheap and as readily obtainable, as pipe.

Heretofore, the objection to pipe has been the fact that it was practically impossible to make suitable electrical connections from a pipe bus. The only fittings available were screwed pipe fittings, which were not adaptable and necessitated the cutting of threads, increasing the labor of erection and weakening the material.



CONNECTORS AND FITTINGS FOR COPPER, IRON AND ALUMINUM TUBING

The line of fittings and connectors recently developed by the General Electric Co. makes the use of pipe for busses and connections a simple matter. With a straight connector the pipe, when used as a bus, can be joined after the lengths are fitted up in the structure. This could not be done readily with screwed fittings. The joint in the pipe can come in the middle of the span, a practice which would not be considered safe with screwed fittings, thereby allowing the use of short pieces of pipe, eliminating waste.

The tee-connector has a wide use. It overcomes the necessity of cutting a pipe bus when making a tap, which would have to be done with screwed fittings. It can be secured to meet any condition in the difference in the size of the bus or connection. Wire and cable connections can be used with pipe busses with this contactor by employing a terminal plug to take up the difference between the outside diameter of the wire or cable and the inside diameter of the iron pipe size connector.

The angle-connector enables pipe conductors to be

*Switchboard Department, General Electric Co., Schenectady, N. Y.

used for any kind of connections and saves a great amount of work in erection, because the pipe does not have to be bent into shape before being put into place.

The bus-hanger provides a ready means of attaching pipes to Hewlett insulators in suspension. The hanger is adaptable to the Hewlett hardware and is attached quickly and easily.

Connecting pipe to disconnecting switches has been a difficult proposition until the disconnecting switch terminals for pipe were available. These readily solved the trouble, thereby eliminating extra labor in the erection of a substation, which would be necessary without the use of these terminals. This is also true with the use of oil circuit breaker and transformer stud terminals.

Pipe fittings are made in either bronze or aluminum alloy. The bronze fittings are recommended for use with copper tubing, and the aluminum with iron pipe. This distinction has been made to guard against any possibility of disintegration due to galvanic action that may be encountered in humid climates, but which may not be serious in this type of construction. Aluminum fittings, however, are cheaper and, with the revised specifications of this material, should be extremely satisfactory.

In using pipe for busses and connections, care must be taken to allow for the expansion and contraction of the rigid pipe by clamping the conductor at the middle support only. Special care should be used in connecting to transformer or oil circuit breaker bushings that sufficient loop is allowed in the conductor so that no strain may come on the bushings due to the settlement of the oil circuit breaker or transformer foundations, independent of the structure. When the value of the current permits, the use of wire connections to oil circuit breaker and transformer bushings is recommended.

Prevention of Explosions in Air Receivers*

Gas Is Usually Formed in Such Small Amounts That No Trouble Arises Unless It Accumulates. By William F. Parish and William B. Smith Whaley

IT IS GENERALLY conceded that air receiver and line explosions are caused by explosive mixtures due to air and, primarily, the lubricating oil, but no research is had to date that suggests a positive remedy. It is suggested that less oil be used; obviously too little lubricant may lead to disastrous results through overheating of the parts and causing mechanical damage to the bearing surfaces without improving the situation in regard to the forming of explosive vapors. Explosions formerly were followed by a demand for a higher flash point oil, until it was found that the use of such oils did not reduce the trouble.

With all of the mineral oils, from the lightest to the heaviest, some decomposition takes place under the heat and pressure in the air compressor cylinder and valve chests. Carbon residues, when examined, have always been found to be composed of free oil and carbonized oil in almost equal proportions. There is generally about 10 per cent of foreign matter, such as iron and other metal from the wear of the compressor parts, with some rust. Dirt and particles of raw material from about the plant are also found, such as coal dust, cement, fibers and vegetable material. The entire amount of deposit is held together by a binder formed from the sticky part of the burned lubricant.

These residue deposits, of themselves, sometimes cause air line failure and they can materially aid in the formation of the more volatile oil vapors out of the heavier vapors by their action as catalyzers. It has been shown that deposits will materially lower the ignition temperature of vapors in an air line. When an air line starts to fill up with this deposit, which is generally at some point of natural obstruction, the restricted passage forms a trap and allows the collection of the vapors and oil. When conditions are right an explosion or a series of explosions of non-violent nature then take place which can be dissipated along the lines and cause no material damage. The heat of each explosion, however, bakes the carbon residue formation hard and finally overheats the pipe so that it eventually ruptures.

Visible evidence of oil decomposition that is present in these carbon residue deposits proves the existence of a series of highly explosive gases and volatile vapors that have been liberated during the decomposition or cracking of the lubricant. These vapors can, in fact, be recondensed into the familiar petroleum products, benzine, gasoline and kerosene. Some of the gas is so light that it cannot be easily condensed. All vapors and gases released by the decomposition of the lubricant are highly volatile and explosive when mixed with the proper proportion of air.

In all air compressors the lubricating oil, of whatever nature and however fed, is undoubtedly finely divided and atomized at the time it leaves the air cylinder. The heat conditions are such as to thin any oil and the swift action of the air, the pressures and heats of compression together with the working of the pistons and valves, will not only thoroughly atomize the oil, however heavy, but will decompose certain parts of it. When this action takes place a small amount of free oil in a highly atomized state is liberated into the air passage.

Total amount of vapor and gas is so small, as compared to the total amount of air handled, that it would present no problem if it did not accumulate. A highly explosive and critical area is present in every unscavenged static receiver or tank when air and combined combustible vapors and gases are present as is the case in air compressor receivers. This critical area exists at some point between the tank bottom, where the heavier parts of the atomized oil will settle out, and the top strata, which contains the most volatile gases. Wherever the mixture of air and volatile vapor is in a critical condition and is in contact with metal, the slightest external shock may cause detonation.

Should the area of critical mixture lie in the center of the tank surrounded by free air, it will be safely cushioned. Should the tank contain a sufficient amount of combustible vapors, lying in strata as suggested, ignition of the unstable and critical mixture can take place and due to the over richness of the adjoining lower strata and over leanness of the adjoining upper strata the action may not go through the entire contents of the tank and the increase in pressure will be within the limits of the safety valve. If the conditions are such that detonation of the critical mixture will fire the entire series of strata, the result will

*Abstract of paper read before the Metropolitan Section of the A. S. M. E.

necessarily be a violent explosion due to heat and pressure being generated in excess of the capacity of the safety valve.

Explosions Are Not Always Prevented By Safety Valves

Safety valves, as such, come into action after the explosion takes place. They do not prevent the formation of volatile vapors and gas that causes the explosion. These valves prevent some explosions but as they cannot and do not prevent all explosions they must be considered only a partial remedy. It is, and has been obvious for years, that explosions will not occur if air and oil vapors are prevented from accumulating and forming combustible gases. The remedy lies in introducing preventive measures. Pockets and traps can be guarded against in the air lines. As regards the receiver, we can introduce means for constantly scavenging the tank and thus can prevent the accumulation of oil vapor and vapor mixtures and thereby prevent explosions.

This receiver scavenging method was developed as the direct result of an explosion. When applied to air receivers where explosive mixtures should form it has prevented their formation over a period of 7 yr. The details are of interest in this connection. While working on one of the experimental engines of a new cycle, an explosion took place in the 12 by 24-in. air receiver for 200 lb. air. Force was generated that was sufficient to blow out a fitting in the line at the compressor cylinder. The receiver and the oil in it was held for further experimentation and a new fitting was made much stronger than the first. All parts of the system were strengthened and a pop safety valve was put on the line. The engine was then started and within 2 hr. the mixture again carbureted in the receiver, the explosion being of such force as to increase greatly the temperature of the receiver; the safety valve in this instance relieved the pressure before damage was done. The oil in the receiver was not burned and the temperature rise did not take place before the safety valve blew off. The gas and combustible vapors did not come from the oil that had already collected in the receiver, because in this case a temperature in excess of 500 deg. F. would have to be maintained for a long enough period to heat the entire body of the oil to that degree before ignitible vapors would have been produced.

In this case temperature was not noted until after the explosion and then much less than would have been necessary to secure vapors from even a small amount of the kind of oil used on the engine. A scavenging valve was then made and placed on the air receiver. With this valve the air enters and leaves the receiver through the same opening. The mechanism of the valve allows the pressure to open a passage for the compressed air to the top of the tank. The outlet opening has fitted to it a length of pipe that goes to within a few millimeters of the bottom of the tank. Any air flowing from the pump or compressor to the air system, therefore, has to pass from the top of the tank entirely to the bottom before it can leave. This effectually sweeps all vapors and gases from the receiver and keeps it full of pure fresh air with only a minute amount of oil and vapors that, however, do not have a chance to collect and stratify.

Soot accumulation on boiler tubes or flues should never be washed off with water, as the water will have an exceedingly detrimental effect upon the brick boiler setting.

Test Methods for Enameled Electric Wire

On JANUARY 26, at the meeting of the French Academy of Sciences, M. J. Cathala read the following notes:

The use of electric wires insulated by a coating of enamel or of insulating varnish has developed considerably in recent years on account of the many advantages of this method of insulation.

Apparatus has been devised to reveal the points on the wire at which the insulation is defective. It consists of a drum B driven by a motor of 1/10 hp., the speed of which can be regulated by a rheostat R. This drum draws at the same time the wire to be tested and the registering paper at different speeds such that the wire passes over 400 units of length while the registering paper passes

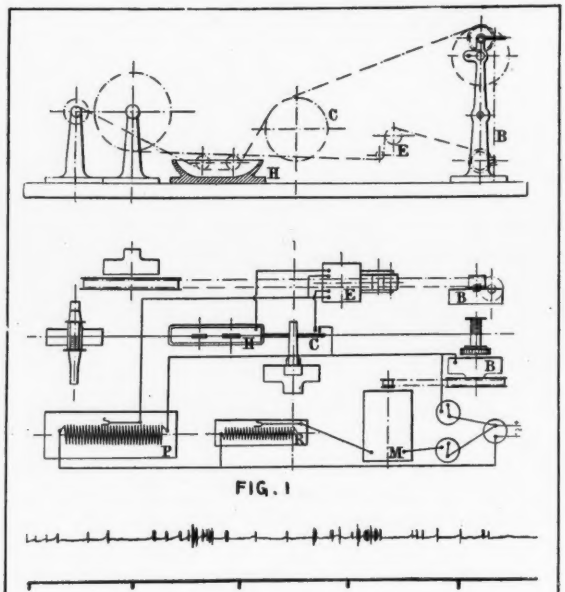


FIG. 1. SCHEME OF APPARATUS USED TO SHOW DEFECTIVE INSULATION

FIG. 2. GRAPH AS RECORDED BY INSULATION TESTING APPARATUS

over one. The wire makes a complete turn around wheel C, without any slip, then passes through the mercury bath. It is then wound on a spool. Through this spool the wire is connected to one of the poles of the testing circuit. The bath of mercury is connected to the other pole through one of the electromagnets of the registering device E. The wheel C has a circumference of exactly 19.685 in., and at the end of every 20 turns it releases a contact closing the circuit of the other electro-magnet E. The length of wire is thus marked off in units of 32.8 ft. A graph is recorded on which can be seen not only the total number of defects but also their position in relation to the ten meter divisions.

Correctness of the apparatus can be tested by passing the same wire through twice and then comparing the two graphs, which should of course be identical. By using a number of mercury baths, each one connected up, and by interposing a twisting or bending device between each, the behavior of the enamel or insulating varnish under different kinds of stress can be accurately shown.

Harbor Point Station Will Operate First Unit in 1926

CONSTRUCTION IS WELL ADVANCED ON 60,000-KW. PLANT OF UTICA GAS AND ELECTRIC CO., WHICH MAY ULTIMATELY BE ENLARGED TO 150,000 KW.

CONSTRUCTION OF the new 60,000-kw. Harbor Point Station of the Utica Gas & Electric Co., Utica, N. Y., is progressing in order to have the first 15,000-kw. unit on the line January 1, 1926. The steel structure is complete, about one-half of the brick superstructure has been finished, and the entire building will be roofed in by Sept. 1. It will then be possible to proceed with the inside work without any danger of a "tie-up" from cold weather.

Building and water facilities are being constructed for 60,000 kw. capacity with a possible expansion to 150,000 kw. The initial installation will consist of two 15,000-kw. turbo-generators, followed by a third machine of 30,000 kw. capacity. According to the present plans all additions to the original installation will be 30,000-kw. units.

On completion, the station will operate primarily as a standby for a hydro-electric system. The system growth, however, will be handled by the steam plant until the expenditures for additional hydro-electric developments are justified.

At present the output will be transmitted at 13,800 v. directly through protected feeders to a switching station 2000 ft. from the site, but upon the addition of the third unit an outdoor substation will be built adjacent to the station for tranmission of power at 66,000 or 110,000 v.

Main equipment for the initial installation will consist of two 15,000-kw. Westinghouse turbo-generators, each unit equipped with a 20,000-sq. ft. C. H. Wheeler surface condenser. Condenser auxiliaries, as well as other auxiliaries throughout the station, are in duplicate, having both electric drive and steam turbine drive. Exciters are mounted on the shafts of each unit, each exciter being capable of exciting both units, an additional 250-kw. turbine-driven exciter serving as standby.

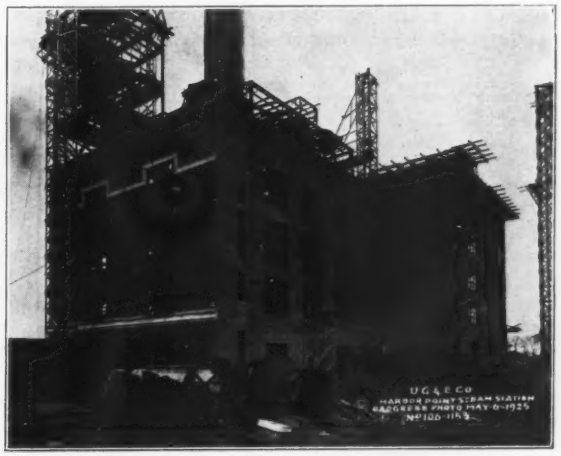
BOILERS ARE EQUIPPED WITH FIN-TUBE WATER SCREENS

Four 1610-hp. Connelly cross-drum boilers are being installed, equipped with "C-E" Fin-tube water walls on two sides, with Power Specialty Co. cast-iron water backs in the bridge wall. These walls and water backs will increase the heating surface approximately 500 sq. ft. in each boiler. The boilers will be equipped with Elesco superheaters, and furnish steam at 275 lb. gage, 125 deg. superheat, at the turbine throttle, which is a total steam temperature of approximately 540 deg. F. Three boiler feed pumps, manufactured by the Platt Iron Works, two with Terry turbine drive and one with motor drive, will furnish the boiler feed water in connection with two high-pressure and two low-pressure Croll-Reynolds closed heaters. Each boiler will be fired with a 14-retort, 33-tuyere Taylor Stoker with double roller crushers, furnished by the American Engineering Company. Coal handling equipment of 200 T. per hr. capacity is being installed by the Maine Electric Co. This equipment is capable of supplying coal for the ultimate capacity of the station. A hydraulic system of ash disposal will be installed.

On account of poor soil conditions, it was inadvisable to adopt tunnel construction for the circulating water, therefore cast iron pipe supported on piled concrete mats has been installed. Two 42-in. suction lines serve the condensers, the pumps being in the main turbine room basement. The water enters through a revolving screen in a well house at the river. The condensers discharge through a reducing manifold on the opposite side of the station through an 84-in. cast-iron pipe. A connection from the discharge manifold is carried to a point above the intake to recirculate hot water from the discharge, to prevent freezing at the intake during the winter.

ESSENTIAL AUXILIARIES ARE CONNECTED TO GENERATOR LEADS

Essential turbine auxiliaries will be supplied from a 300-kv.a., 3-phase, high-reactance transformer, connected directly to the generator leads. The other station auxiliaries will be supplied from a 1500-kv.a., 3-phase transformer connected to the 13,800-v. bus. The 13,800-v. bus



VIEW OF HARBOR POINT STATION FROM THE NORTH, SHOWING STEEL ERECTED ON COAL-HANDLING TOWER AND ONE STACK IN PLACE

is designed for a ring arrangement in the ultimate station with interlocks provided on the sectionalizing oil circuit breakers, so that at no time can two machines be operated in parallel except through reactors. The main switching equipment will be furnished by the Westinghouse Electric & Manufacturing Co. Oil circuit breakers with a rupturing capacity of 1,500,000 kv.a. will be used on generators, transformer banks, feeders to the switching station, and synchronizing bus. Metropolitan Device Corp. current-limiting reactors will be placed on both generator leads and out-going 13,800-v. feeders. The 250-v. storage batteries will be furnished by the Electric Storage Battery Co., one for control and the other for emergency lighting, with motor-generator sets for charging them. Station lighting will be furnished from two 200-kv.a., 3-phase, 460/115-v. transformers with 20-kv.a. voltage regulators, connected on the 460-v. side. These transformers are connected to duplicate auxiliary power busses and arranged so that only one transformer can be operated on the same bus at one time.

PLAYTIME is getting to be synonymous with night-time. Great electric floodlights are now used in many sports—tennis, golf, croquet, trapshooting and motorcycle racing. The moonlight, however, is still reported to be the favorite with lovers.

Steel Stack Reinforced While in Service

AT WAUKEGAN, Ill., the Public Service Company has a power station known as No. 1 Station. The boilers are served by three self-supporting steel stacks 9 ft. inside diameter—one being 200 ft. high and two being 180 ft. high.

All rest on concrete foundations immediately to the rear of the boilers and extend through the roof of the power house about 35 ft. above the ground. The center one of these, 180 ft. high, began to show signs of weakness due to corrosion some years ago. Steel bands 5 ft. apart were placed about it, about half way between the roof and the top, and from these bands guy wires were run to the two outside stacks and to the roof.

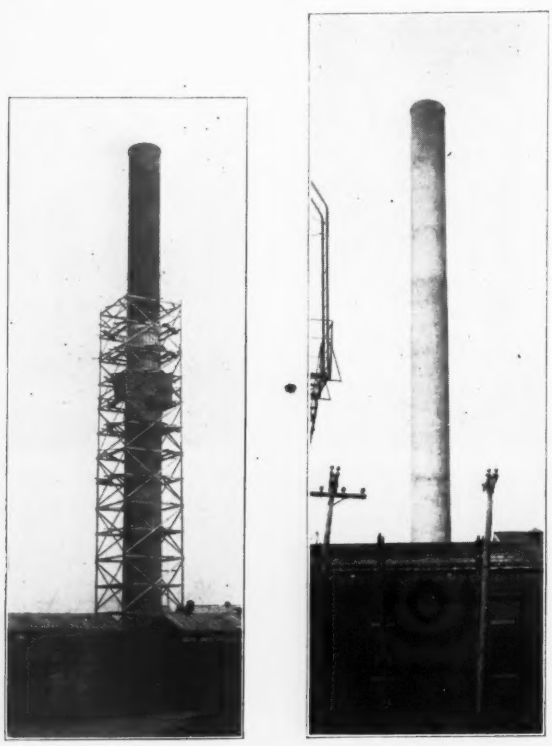


FIG. 1. SCAFFOLD, STEEL STRUCTURE AND GUN-CRETE WERE CARRIED UP TOGETHER

FIG. 2. THE COMPLETED STACK IS SELF SUPPORTING

In the fall of 1924 the engineers decided the stack was becoming dangerous. To let the stack go through another winter was considered risky. To take it down and replace it would not only be expensive but undesirable from the standpoint of shutting down one-third of the plant.

It was decided to conserve the stack by building around it a Gun-crete stack. This work was done by the Cement-Gun Construction Co. of Chicago, one of the stipulations being that there was to be no interruption whatever in the regular and continuous service of the stack during the progress of the work.

A new reinforcing structure was designed, made of steel rods calculated to take all the stresses so that the new stack would not depend on the old stack for any of its support. This was anchored to the old foundation by means of the existing foundation bolts, which were extended by means of sleeve nuts and 1½-in. rods. Added to this structure of rods was a wire mesh fabric designed to distribute the stresses more evenly and carry the green Gun-crete until it had set.

Immediately next to the stack and inside of the reinforcing structure a layer of asbestos board was wrapped around the hot steel stack. This acted as a compressible sheathing so that contraction and expansion stresses due to the varying temperatures of the steel stack might not be immediately communicated to the Gun-crete stack which would respond more slowly to changes in temperature.

Gun-crete was then shot into place, using the old stack as a form to shoot against, the Gun-crete being 8 in. thick at the bottom and tapering gradually to 4½ in. at the top.

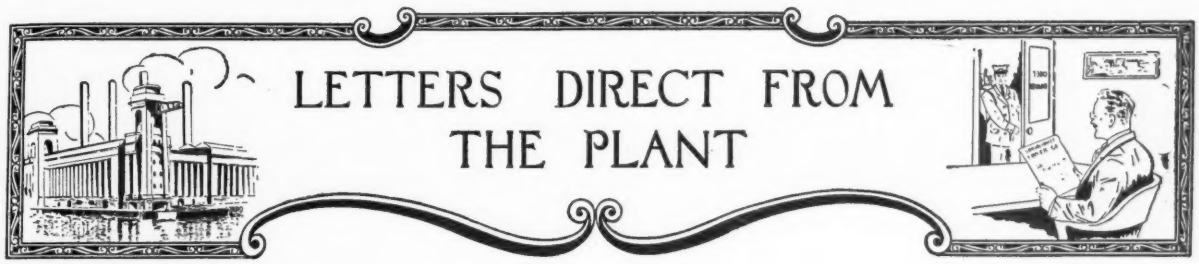
This Gun-crete was a mixture of 3½ parts of No. 2 torpedo sand and one part of Portland cement shot into place with cement guns, at a pressure of 50 lb. per sq. in., using a 14 by 12 single stage compressor driven by a 60-hp. motor.

Figure 1 shows the stack about two-thirds completed. The weather was beginning to get cold and there was very much high wind during the progress of the work. The guy wires were therefore left in place until the new structured had attained its strength, and much of the time the work had to be done behind canvas protection, as shown in the picture. Scaffold, steel structure, and Gun-crete were carried up together, and guy wires were removed only as the Gun-crete was completed.

Figure 2 shows the completed stack with all guy wires removed.

EXTRAORDINARY EXPANSION of the services of public utilities in recent years has been a notable feature of the country's industrial progress, says the Guaranty Trust Co. of New York, in its monthly publication, the "Guaranty Survey." "The rapidly growing demand for these services has necessitated additional and improved plants and equipment and more efficient organization of facilities," states the "Survey." "This situation is reflected in the flotation of new securities of public utility corporation. Last year the public offerings of such securities in the United States totaled $1,530,000,000, of which all but about $200,000,000 represented new capital as distinct from refunding operations. The volume of such new capital investments was larger by $438,000,000, or 49 per cent, than in 1923, and was three and a half times that in 1920. The importance of these securities is further indicated by the fact that they constitute 40 per cent of the total new capital issues of all classes of corporations. The volume of public utility issues in the first quarter of this year was even more striking. Their total of $615,000,000 is nearly twice the figure for the corresponding months of 1924. The increasing popularity of public utility securities has been a conspicuous feature of the investment market since 1923.

"Lower prices of coal as affecting their expenses, the inter-connection of electric power systems and the generally high level of business activity contributed to the favorable showing made by these companies. There is evident, moreover, a broadening appreciation of the significance for the investor of the comparative stability of utility earnings generally in periods of business depression."



Overcoming Vibrations Caused by Steam Engines

In the March 1 issue, page 302, I noticed an article by J. O. Benefiel, describing a problem in pipe vibration which is similar to a condition that developed in our plant after installing a new engine. The vibration did not start all at once but seemed to develop gradually until it reached a point where decisive action was necessary.

When I was first employed in this plant the same boilers were there but they had an old 18 by 48-in. Corliss engine that made only 72 r.p.m. The boilers "heaved," as the man in charge expressed it, but at that low speed no damage was done. When we decided to generate our own electricity the old engine was found too small, since there was a city ordinance which provided that "the power rating of a generator must be as large as the total power rating of the motors installed in the plant."

Since it required a 250-kw. generator, the old engine was discarded and a new one of the Corliss non-releasing type, 20 by 24-in. and 200 r.p.m., was direct connected to a generator of this capacity. At first there was scarcely any vibration, but in two years it became extremely severe.

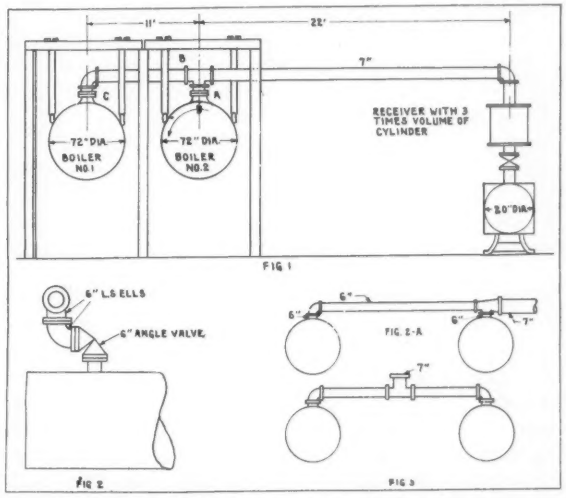
The boilers are set as shown in Fig. 1. Each setting is entirely independent of the other, except that the columns in the center support the cross I-beams of both boilers. Either one, however, can be dismantled without disturbing the other. The original supports were of 5/16 by 8-in. channel beams placed back to back with spacers between. They were apparently too light, for when finally removed they were found with a permanent set or sag in the center of about 3/8 in. Double 1/2 by 10-in. I-beams were then tried.

These seemed to help for a while but soon it was as bad as ever. At times No. 2 boiler seemed to have a rotary motion, as indicated by the arrow in Fig. 1. The strain was so great that one day the buck stay in the center of No. 2 setting broke. Something had to be done at once. The header was all in a straight line with the connections to each boiler formed as shown in Fig. 2. A 6-in. pipe ran from No. 1 boiler to the tee above No. 2 and from there to the receiver it increased to 7 in. This is shown in Fig. 2-A. There was a 7-in. exhaust pipe leading into the heater which carried 5-lb. back pressure. The engine was rated at 375 hp.

The asbestos covering on top of both boilers was in bad shape and the boiler inspector wanted to inspect the outside of the shells under the covering, so the material was stripped off and enough more added to put on a coat 3 in. thick. One layer of brick was laid in mortar over the asbestos and finished with a coat of air-tight boiler wall cement.

No trouble has ever been experienced since that time, but once in a while, when the engine gets to working hard, the hand of the steam gage of No. 2 boiler will vibrate in unison with the cutoff of the engine. Although the engine was rated at 375 hp. at 175 lb. pressure, we are allowed a pressure of only 110 lb.

Now all that I can figure out is that the additional weight added by applying the asbestos and brick was just enough to break the rhythmic vibration set up by the engine when it cut off. Although the header is as rigid as possible, the size seems to be ample and the receiver is



METHOD OF SUSPENSION AND HEADER CONNECTIONS CAUSED VIBRATIONS IN H.R.T. BOILERS

3½ times the capacity of the engine cylinder, so that it does not seem reasonable to blame under size pipe or receiver capacity.

In another case of vibration with which I had some dealings, the pounding was so terrific that it was difficult to keep anyone on the job. There were two headers on these boilers, the first of 6-in. diameter supplied steam to the main engine and the other of 3-in. diameter supplied steam for all auxiliaries. A 10-hp. engine running at 325 r. p. m. also took steam from this 3-in. line. We decided to change the connection so that it would take steam from the 6-in. header and immediately there was a noticeable diminution in the violence of the vibrations. Finally, by putting all the auxiliaries on the main header, the vibrations could scarcely be felt.

In this case I believe the amount of steam used by the auxiliaries was sufficient to break the regular pulsations set up by the larger engine.

In both cases an indicator attached to the header between the nearest boiler and the engine showed scarcely a trace of fluctuation in pressure, but when attached to the boiler it told a different story. As nearly as could be

figured the flow of steam from No. 1 boiler through the header at right angles to the nozzle connecting No. 2 boiler caused a sort of dampening or blanket effect to the steam coming in from No. 2 boiler. Every time the engine cut off there appeared to be a kick back on No. 2 boiler which did not show up in quite such pronounced manner on No. 1.

In still another instance in a plant of two boilers a remedy was applied as shown in Fig. 3. This scheme permanently remedied the trouble by apparently drawing the steam in equal amounts from each boiler.

Minneapolis, Minn. FRED. S. RUTLEDGE.

Corrosion by Oxygen Proved by Practice

AFTER ALL the years of discussion and controversy over the question of the cause of boiler corrosion and after the development and widespread adoption of equipment designed to stop corrosion by removing oxygen from the boiler feed water, it is rather surprising to have F. F. Vater, in your April 1 issue, claim that oxygen does not cause corrosion. He cites examples showing much oxygen and little corrosion, and others showing less oxygen and serious corrosion. In the June 15 issue, H. R. Williams offers Mr. Vater possible explanations for the apparent discrepancies in the oxygen theory.

I do not believe that it is questioned any longer that corrosion may be caused by oxygen in the boiler feed water. Of course, you can always find cases where there is plenty of oxygen present but where little corrosion trouble has been experienced. These are the exceptions, not the rule, and it will usually be found in such cases that there is some other condition at work to prevent corrosion, such as a thin coating of scale which protects the steel against the corrosive action. Some of the boiler compounds claiming to insure a boiler against corrosion at least partially make good their claims by forming a thin film on the tube. High velocities, which discourage any lodging of gas bubbles in a given place, may minimize pitting at that place as compared with some other portion of the boiler where movement is not so rapid. But in general it has been demonstrated that oxygen in the feed water will pit boilers whenever it gets a chance at the bare steel.

Large central stations have proved this so thoroughly to themselves that they have spent many thousands of dollars for equipment designed for no other purpose than to remove the oxygen from the boiler feed water and they have found that this equipment pays handsome dividends, because it reduces the necessity for taking large boilers off the line and replacing pitted tubes. Companies of this sort are not in the habit of spending money repeatedly for equipment that serves only as an ornament in the power plant.

Owners of hotels and apartment houses find that the removal of oxygen from the feed to their hot water heating systems gives an almost indefinite lease of life to the water piping, and makes brass pipe unnecessary. It will often be found that private power plants can reduce corrosion materially without any additional expense whatever. It is common to find a plant operating with the feed water heater at 208 deg. F. and with a back pressure of one pound in the heater. At this back pressure water boils at about 215 deg. F., which means that the actual water temperature delivered is 7 deg. below the boiling point. Under these conditions the water contains about one-half c.c. of dissolved oxygen per 1000 c.c. of water. This proportion of oxygen can easily cause serious corrosion in feed lines or in boilers.

The remedy in this case is to vent more steam from the heater. The extra amount of vented steam will sweep out the air which is liberated when the water is heated, thus reducing the "air partial pressure," as it is called, and allowing the water to be heated within a few degrees of the boiling point. This will be found to reduce corrosion materially. Central stations have found, in many cases, that even at 2 deg. below the boiling point, about 0.2 c.c. of oxygen remaining in solution will cause troublesome corrosion, but under ordinary plant conditions this will be found a permissible figure.

If there is an excess of exhaust steam, the extra vented steam can be allowed to waste; if the exhaust is needed, a vent condenser can be had at no great expense which will accomplish the same sweeping-out results, but will return the heat in the steam. In occasional instances it will not be feasible to heat the feed water to much above 200 deg. because of a lack of head on the boiler feed pump. In such cases it will usually pay to go to some trouble to get additional head on the pump, either by lowering the pump or by raising the heater. The reduction in corrosion resulting from the higher feed temperature will amply repay any such trouble, as a rule.

Corrosion by oxygen has been proved so many times that it is no longer a matter for conjecture or for personal opinion.

North Glenside, Pa. W. J. RISLEY, JR.

Steam Gage Piping Important

I WAS CALLED to a power plant to locate trouble in connection with the safety valve and the steam pressure gage. Sometimes the valve would blow at the pressure for which it was set, namely, 150 lb., at other times it would open at apparently lower pressure.

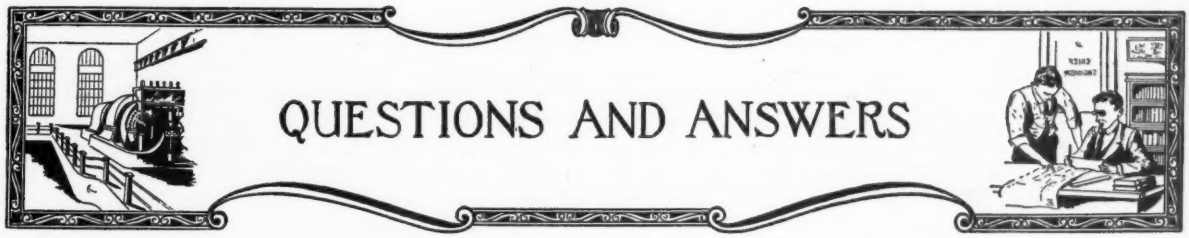
After a bit of experimenting, the trouble was located as being in the ¼-in. pipe connecting the gage to the boiler. A careless pipe-fitter had neglected to ream out the ends of the pipes after cutting them with an apparently defective wheel pipe cutter. This had left the ends of the ½-in. pipes nearly closed. Collected rust or sediment had further reduced the openings until the pipes were almost completely filled.

The habit of using ¼-in. pipe to connect pressure gages is, in my opinion, a bad one. In my experience, I have come across numerous instances where such ¼-in. pipes have been the cause of many near accidents. Every boiler under my charge during the past 20 yr. has had ⅜-in. or ½-in. pipe supplied for this purpose. I dispensed with the bent circle trap and used either elbows or a return bend to form a trap. Such a trap is quite as efficient as the bent pipe form, and can be made to look as neat as does the latter. I have never seen or heard of a ½-in. pipe connection to the gage being closed by scale or sediment and have never seen, and seldom heard of a ⅜-in. pipe causing trouble.

Cost of installing the larger pipe is little more than the cost of the smaller size. Some boiler inspectors in Canada refuse to permit pipes smaller than ⅜-in. to be used for this purpose. Personally, I agree with them.

The subject of proper pipe connections to steam gages is important but never has received the careful attention that it should. In the interests of safety it should be a primary consideration.

Toronto, Canada. JAMES E. NOBLE.



QUESTIONS AND ANSWERS

Is Concrete Suitable for Boiler Settings?

RECENTLY there has been considerable discussion concerning the successful use of concrete as a boiler setting material. Several well known concerns have already installed boiler settings of concrete. We are contemplating building a new plant and are going to use concrete in setting the boiler. We also want to gather all the information possible, for if reports are favorable, we intend doing some research work along this line and would like comments from as many readers as possible as to the successes or failures that they have had with concrete boiler settings.

Chicago, Ill. I. S. P.

What Causes the Leaky Check Valve?

IN THE PLANT which I have charge of we have been having trouble with one boiler taking more water than the others. After obtaining a recording thermometer and installing it on the feed line, we obtained chart No. 1, shown

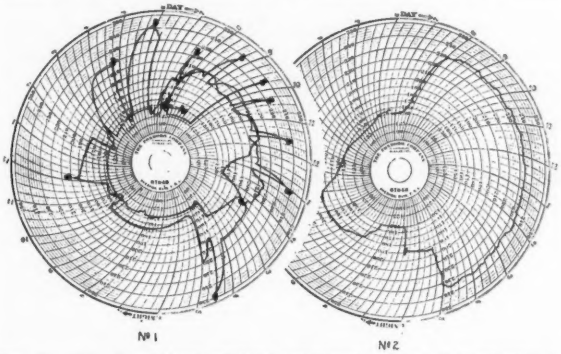


FIG. 1. NO. 1 CHART SHOWS FLUCTUATIONS IN TEMPERATURE DUE TO LEAKY CHECK VALVE. NO. 2 CHART SHOWS CONSTANT TEMPERATURE DURING OPERATING HOURS

in Fig. 1. This was allowed to run for two days and showed the temperature to be exceedingly erratic, with a number of high peaks designated as "B." This led us to look for a leaky check valve on the branch line to No. 1 boiler, since it was suspected that this defective valve allowed the water to run back out of the boiler into the feed line and from there into No. 2 boiler. This caused the water to get so hot that it would become steam-bound and even stop. This is what caused the high peaks.

In this particular case, the strange part is that No. 2 boiler has had the same check valve on the branch feed line for about 12 years and it has never leaked and is still in good condition, while there have been several replacements to the one in No. 1 feed line. Before it was definitely decided that the trouble was due to a leaky check valve, No. 1 had the reputation of being an exceptionally good steamer. After assuring ourselves that the check valves to both boilers were in good order no appreciable variation of the water level in either boiler could be observed within a reasonable length of time. Chart No. 2 (Fig. 1) from 8:00 a. m. to 5:00 p. m., while the engine was operating, shows a practically constant temperature as always found when the check valves are in good order.

We now use checks having renewable discs, which are examined every time a boiler is washed. As stated before, No. 2 has never leaked, although the disc is renewed occasionally, just to be on the safe side, but No. 1 has to

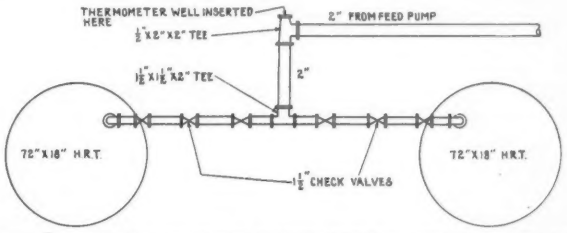


FIG. 2. DETAILS OF FEED WATER PIPING AND METHOD OF INSTALLING CHECK VALVES

have a new disc every time we inspect it and occasionally the seat must be refaced. Why this check should give so much trouble and the other none is something I can't figure out. The water is taken from an open feed water heater and the pump is 9 ft. lower than the bottom of the heater. From the pump it is piped to a point where it branches to each boiler, as shown in Fig. 2. There is an equal number of feet of piping in each branch line and the feed pipes extend the same distance into each boiler. If there was any difference in the piping, I might lay it to that. I have run across several cases of this kind and in every one found leaky check valves on the feed water line. There are no feed water regulators on these boilers. The exhaust steam is used for heating purposes and back pressure is maintained in the heater.

Minneapolis, Minn. FRED S. RUTLEDGE.

Why It Is Cheaper to Generate Steam at High Pressure

DOES IT take more heat to raise water to steam in a boiler from 55 to 212 deg. or to raise it to steam from 212 deg. to 150 lb. gage pressure? F. S. R.

A. It requires more heat in the first case, for, although the sensible heat imparted to the water is practically the same, the difference in the total number of heat units is accounted for by the fact that the value of the latent heat of vaporization changes materially as the pressure is increased. At atmospheric pressure this value is approximately 970 B.t.u. At 150 lb. gage pressure it is reduced to 875 B.t.u., at 600 lb. absolute it is reduced still further to 742 B.t.u.

If you take the figures in your problem as stated, but include the condition of raising the water into steam, we

shall find that to raise water from 55 deg. into steam at 212 deg. we shall have 23 B.t.u. in the water above 32 deg. when fed at 55 deg., and the total heat of one pound of steam at 212 deg. is 1150 B.t.u., so that the difference between 1150 and 23 is 1127 B.t.u., which had been added to produce a pound of steam. In the second case we find that there will be 1195 B.t.u as the total heat of one pound of steam at 150 lb. gage pressure, and since there are 180 B.t.u. above 32 deg. when the water is fed in at 212 deg., then the difference between 1195 and 180 is 1015 B.t.u., showing that as the pressure increases it takes less heat to evaporate a given amount of water, although the sensible heat required to bring it to the boiling point may be the same in both cases.

Here we have 1127 B.t.u. required in the first case and 1015 B.t.u. in the second. There is a difference of 112 B.t.u. If we take 1015 B.t.u. as the standard, then in the second case we shall have 11 per cent less heat required.

What the Cards Show

REPLYING TO the inquiry, "What Do the Cards Show," by R. H. M., page 713 of the July 1 issue, I would say that all the events are too late in the high-pressure cylinder of that engine. The lead is late at both ends of the cylinder, as indicated by the inward slope of the lead lines at both the head and crank ends. The steam lines and the points of cutoff are good, and probably fulfill the intention of the designer of the engine in question.

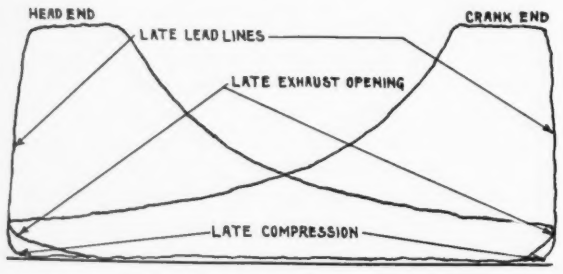


FIG. 1. INDICATOR CARD FROM 25 BY 48 IN. HIGH-PRESSURE CYLINDER OF A CROSS COMPOUND ENGINE AT 63 R.P.M., RECEIVER PRESSURE 3 LB. SHOWS ALL EVENTS TOO LATE

The expansion curves also are good and probably approach the true curve as closely as consistent in practice. The exhaust opening at both head and crank ends are too late, as indicated by the sloping back pressure lines at the "toe" end of both diagrams.

Back pressure lines in both head and crank end diagrams are all right, with the exception that the exhaust is closed too late at both ends, as indicated by the extremely small rounding at those corners of the diagrams.

These diagrams show a combination of good and bad points in the steam distribution in the engine. The outlines of the diagrams show that the valve is correctly placed on the valve stem, and as the events all lean one way—late—the remedy lies in advancing the eccentric which drives the valve.

Just how much the angle of advance of the eccentric should be increased can best be found by trial. For a starter, considering the size and dimensions of that engine, I am of the opinion that the eccentric could be moved ahead about 2 in., circumferentially measured on the shaft.

The difference in receiver pressure, as mentioned by R. H. M. and as indicated by the proximity of the atmospheric lines to the back pressure lines in both sets of diagrams, has nothing to do with the late steam events that have just been discussed. That is an entirely different matter. Changing the eccentric as suggested will make an all around improvement in that particular cylinder.

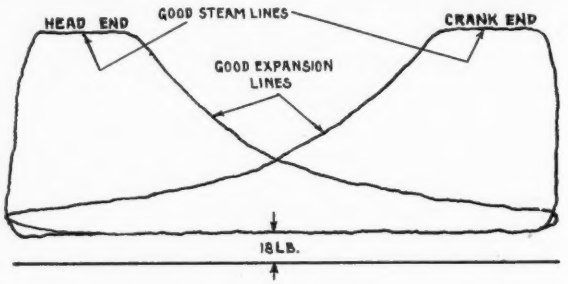


FIG. 2. INDICATOR CARD FROM SAME ENGINE AT 82 R.P.M., RECEIVER PRESSURE 18 LB. ALL EVENTS TOO LATE

Whether or not the 18-lb. receiver pressure is as it should be, can be told only by analyzing diagrams from the low pressure cylinder of the engine. It would be well for correspondents requesting information as in this case, to send in a complete set of diagrams from all cylinders, with a complete set of data and particulars, then full and satisfactory answers can be given, and we can be of more help to those who have such problems to solve.

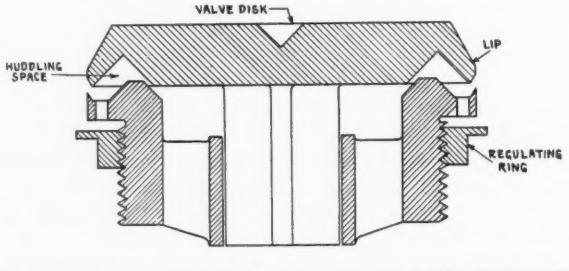
Brooklyn, N. Y. C. J. MASON.

Regulating Ring Determines Amount of Blow Back

WHAT IS a blowoff ring in a safety valve?

B. S.

A. By the term "blowoff ring," we assume that the regulating ring is meant. This is shown in the accompanying diagram. The valve disc has an overhanging lip which



VALVE DISC AND SEAT FOR SAFETY VALVE WITH THREADED ADJUSTMENT FOR REGULATING RING

deflects the escaping steam downward to holes in the outer edge of the seat. This lip affords additional area upon which steam may act when opening the valve. Steam pressure acts upon the valve disc and forces it slightly out of its seat. The steam escaping into the space below the lip of the valve finds its passage to the outer air obstructed. It has to pass out through the holes provided or below the

outer edge of the lip of the disc. Pressure is built up in the huddling space by the simmering of the valve until the combined accumulated pressure and the reaction due to the steam that escapes downward causes the valve to open suddenly or with a pop.

The position of the regulating ring determines the drop in pressure, sometimes called "blow back," required before the valve is again seated. The amount of "blow back" usually varies from 3 to 8 lb. per sq. in. The nearer the ring is to the holes in the valve seat, the greater must be the reduction in pressure before seating.

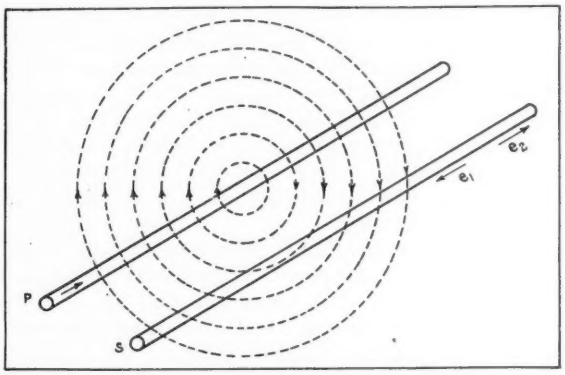
The method of adjustment for "blow back" differs in the various makes of spring loaded safety valves. The principle, however, is the same in all.

In the accompanying diagram, note the threads provided for screwing the regulating ring up and down so as to vary the drop in pressure before the valve seats itself after popping off.

When D. C. Produces A. C.

IF A PULSATING direct current is fed into the primary of a power transformer, will there be alternating current produced in the secondary side? G. H. M.

A. The electromotive force induced in the secondary winding of a static transformer is always an alternating e.m.f., regardless of whether the e.m.f. applied to the primary is alternating or pulsating direct. That this is



PULSATING CURRENT PRODUCES LINES OF FORCE OF INCREASING AND DIMINISHING STRENGTH

so will be evident from a consideration of the accompanying sketch which represents in its simplest form the primary and secondary windings of a transformer. When the pulsating current flowing in wire P is in the direction indicated by the arrow, the direction of the field will be clockwise as shown by the dotted lines of force around the wire.

If we assume this primary e.m.f. to increase gradually from zero, it is evident that as the current becomes stronger the magnetic field due to this current will spread outward, cutting through wire S, and inducing in it an e.m.f., the direction of which may be determined by the right hand rule. In the above case, when the current in the primary is increasing in value, the lines of force cut the wire S from left to right and the induced e.m.f. will be in the direction of the arrow e_1. If, however, we consider the current in the primary to be diminishing instead of increasing, the magnetic field will collapse and the lines of force will cut wire S from right to left. Since the direction of motion has reversed, it is evident from the right hand rule that the induced current will also reverse; in other words, it will be as shown by the arrow e_2.

Thus, it is seen that although the direction of the current in the primary has not changed, the induced current in the secondary has undergone complete reversal, the direction depending upon whether the current in the primary is increasing or diminishing in value.

How to Synchronize the Generators

I am operating an industrial plant having a 120-kv.a. 220-v., 60-cycle, 3-phase, belted generator, which I occasionally use to supply current for the city through transformers which step up the current to 2200 v. The city plant generates at 2200 v. Now I would like to know why the city plant is able to parallel with my generator when I am unable to parallel with them. In other words, when I have the load they can parallel with their lamps and synchroscope easily. When they have the load, no matter how

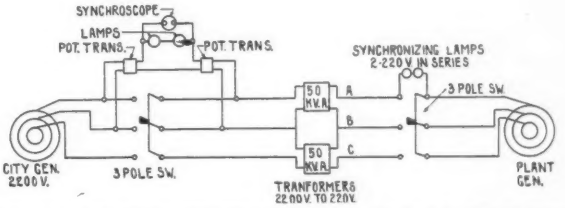


FIG. 1. SHOWING SYNCHRONIZING LAMPS ON ONLY ONE PHASE OF SMALL GENERATOR

I vary the speed of the generator apparently no current will flow through the synchronizing lamps at my plant. What is wrong? Fig. 1 illustrates the method of connections between the plants.

H. L. M.

A. As shown by the sketch you sent, you had an open circuit and naturally your synchronizing lamps did not

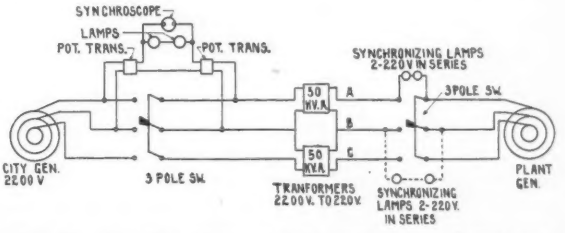


FIG. 2. SYNCHRONIZING LAMPS NEEDED ON 2 PHASES

light. By connecting the other lamps in a series across the switch on phase B, current will then flow through your generator and when both sets of lamps on phases A and B are dark, throw in your switch and your generator will then be in synchronism with the city generator.

The proper hook-up is shown in Fig. 2.

Seal Beach Power Station

IN OUR June 15 issue, the article on Seal Beach Power Station was prepared by C. F. Dixon and R. E. Behnke, whose names were inadvertently omitted from the article. These men are members of the organization of Dwight P. Robinson & Co., Inc., which designed and built Seal Beach Station.

EDITORIAL COMMENT

When Facts Are Presented

Complaints which are all too common in all walks of life are that people who apparently should be interested in certain problems are not attracted to them and that so often when a proposition has been accepted and put into practice the results are not as anticipated.

Can either of these conditions be attributed to an absolute disregard of duty upon the part of those who should be interested? It is safe to answer "No!" for it can usually be found that the true facts have not been obtained and presented in an interesting and understandable way.

For months, the legislature of one of our great states had struggled along with a score of bills, the purpose of which was designed to conserve our fuel resources. In general it was proposed to tap the cheapest sources of power, construct great generating stations and by-product recovery plants at the mines and with mass transmission at high voltage, unify the whole into one great system which would serve, even at great distances, those districts where there was a demand for power.

Certain interests were strongly opposed to this legislation, their contention being that the practices which they were following were as economical, if not more so, than those proposed in the bills before the legislature. They appreciated the fact that their arguments would not win if based upon generalities and that clear-cut facts were necessary to break down the arguments which had already been advanced.

Accordingly they drew upon the information which was at hand and which was based upon the actual operation of two plants, one located at the mine mouth and one near the load center. Both plants were of equal thermal efficiency, each was designed to furnish the same load at the same load factor and to the same manufacturing district. In order to cover the situation thoroughly two problems were presented. One showed the cost of energy transmission by wire from the mine-mouth plant to the manufacturing district where the energy was available at a service voltage. This cost was compared with that of transporting coal from the mine to a plant located near the manufacturing district. In each case the block of power delivered and the load factors were the same.

The second problem involved the same quantity of power generated and delivered under the same comparative conditions as were specified in the first problem. In this instance, however, a comparison was made of the cost of energy generated at the mine mouth, transmitted by wire and delivered to the manufacturing district, as compared to the cost of generation of the same block of power near where it would be used. Both problems gave in full, capital and fixed charges, operation and maintenance, reserve and renewal and taxes and insurance.

In the final analysis it was definitely shown that it cost so many cents to do this and so many cents to do that. Facts had been presented. The legislation was defeated and the legislature adjourned.

Facts had interested the legislators and pointed out the way which, at least for the present, appeared to be right. Think this over and the next time you have a proposition to advance or feel you are justified in opposing the proposition of another, get the facts and present them so they will be recognized as authoritative. After all it is the easiest way, in fact, it is the most satisfactory way to present your proposition no matter how big or how small it may be.

You Can't Catch an Economic Force with a Policeman

Probably every business man in the country has chuckled at the cleverness of Secretary Hoover's apothegm, "You can't catch an economic force with a policeman!" But how many of them, we wonder, have stopped to think that the history of business for the past century has been largely a history of our attempts to obstruct the operation of economic laws, to arrest them with policemen, as it were, and to attempt to punish them under the criminal laws?

For a century we have been saying that big business was bad because it was big. We are still handicapped by the elaborate legal checks and the complicated legal machinery we have set up in our attempt to keep business small. But it seems that we are now discovering that big business is unavoidable.

This is particularly true in the central station field, where mergers of large power companies are taking place with great rapidity. Developments in the art of power transmission make inter-connected systems desirable and result in conservation of national fuel resources, better and more reliable light and power service and lower rates. The public in general now seems to understand these things and to accept these explanations, a situation almost undreamed of twenty years ago.

This attitude is partly due to the educational campaigns carried on by the public utilities themselves and the offering of stock on their holdings to the general public. Last year the public offerings of such securities in the U. S. totaled one and one-half billions of dollars, of which all but about $200,000,000 represented new capital.

Then, too, the electrical industry as a whole has been aided by the adoption of the same general policies by large organizations in other lines. The public is coming to feel that big business is not only necessary but good. New railroad systems, created by mergers, are being stimulated by the Interstate Commerce Commission. The attitude toward meat packers, steel companies and the like has changed. We are beginning to understand that in these days of vast power, rapid transportation and instant communication, our minds operate in wider fields and we cannot possibly limit business to a single city. Big business is not as sinful as it was in the "trust-busting" days of twenty-five years ago.

It seems to us that this attitude of the public is one of the most encouraging signs of the times. For the expansion of big business has followed economic laws and forces. In the past abuses and exploitation have crept in. But the electrical industry has been notably free from the abuses that were just grounds for criticism against other large scale industries. It has, in fact, led the way in suppressing any tendency for such abuses to arise.

For a long time to come there will be a field for the isolated plant, regardless of the growth of central stations. At present only about one-quarter of the total power used is generated in the central station. But the latter has a distinct and clearly marked field, and in that field it is just beginning its development. Its past progress has been due to economic forces and they should not be hampered in their action in the years to come. The electric power industry has served as a splendid example of how those forces can be made to serve the public good.

No, we can't catch economic forces with policemen. If we must have anything in the power industry, let us have more traffic officers to direct those powerful forces into the new highways of business that are being prepared for them.

Off Duty

In the days before a hash house was called a "Luncheon Shoppe" and a plumber was known as a sanitary engineer, people like to be fooled. P. T. Barnum realized this. When the medicine show came to town the populace looked forward to the event and when the "wonder doctor" arrived, between the songs and antics of black-faced minstrels, bought large bottles of Vegetable Root Elixir at—"one dollar for two bottles and your money back if it does not cure anything from writers' cramp to a hopeless case of inoperable cancer." The stuff was useless, harmless and vile, but the old "doc." had a convincing way about him, and his show, as a rule, was good.

The days of the old medicine show are over and the old doc has long since retired on a substantial fortune, but people have not lost their propensity for being fooled. They request only that it be done scientifically. No longer are they satisfied with doc's Vegetable Root Elixir. Such simple hokum no longer has any appeal—not because they have learned that it was useless, but because the scientific touch is lacking. Today, they get it in terms of electron reactions, neurocalometers and auto-condensation. Vitamin extracts and gland rejuvenators have superseded Vegetable Root Elixir, and ultra violet ray apparatus is sold by every electragist.

Now, the value of vitamins and the efficacy of ultra-violet radiation in the treatment of certain diseases are scientific facts which cannot be discounted. In the prevention and cure of rickets, for instance, the Vitamin D and the ultra-violet ray have brought about wonderful results, and it is not with the theory of vitamin action nor with their proper use that we are concerned in this article.

The value of vitamins as regulators of metabolic processes in the body, however, does not justify the tremendous sale of vitamin concentrates sold in drug stores all over the country. These, like the medicine doctor's "Elixir," are harmless enough but most of them contain less vitamins than does one's regular food. The use of ultra-violet equipment too, is becoming a fad which, as Dr. Slosson says, is likely to rival the famous blue glass craze of the seventies. All sorts of ray apparatus are finding a ready sale for the cure of all manner of ailments but it may be said of most of them that they are either too weak to be of any use whatever or too strong to be used indiscriminately and unintelligently. Ultra-violet rays not only tan the skin but exert a profound effect upon the deeper tissues and it requires a specialist and an expert to employ powerful rays of this kind, for they sometimes produce extremely serious effects. Those who want to experiment for themselves in this fascinating field of radiotherapy should stick to the oldest source of such radiation, the sun.

Of Dr. Abrams' electron reaction theory which was foisted upon the credulous public some time ago and which claimed complete diagnosis of a patient's affliction by the electronic reactions of a drop of blood, little need be said as, since Abrams' death, it fortunately is dying out. It was pure hokum, of course, but it carried with it fine, high-sounding terms and many were deluded into thinking it would cure their ailments. Imagine, diagnosing a patient's afflictions from a drop of dried blood! The oscilloclast, that marvelous instrument leased at fabulous rates by Dr. Abrams to physicians for the purpose of electron reaction diagnosis, was found, when examined by a group of electrical engineers, to contain nothing but a meaningless jumble of wires.

In the same category with the oscilloclast is the neurocalometer, leased to chiropractors at the moderate sum of $2200.00 for ten years, for the purpose of locating impinged nerves. Placed on the spine, it is supposed to tell the chiropractor where to do his pushing. This is nothing more nor less than one of those sensitive thermo couples which produces weak electric currents with small changes in temperature. Like the oscilloclast, it is an instrument made purely to enable the user to increase his charges.

Slightly different to be sure, but still the same stuff which made P. T. Barnum rich, is the use of certain electrical terminology by members of the medical profession. Much of it is mere jargon without any real physical significance. In a paper prepared by two physicians, for instance, on the use of electrical apparatus for the treatment of disease, we find that when a patient is placed between two oppositely charged plates, "he is said to be in a state of auto-condensation!" Auto-condensation! Shades of Microfarad, what next! Isn't that enough to make the Goddess of Science weep?

With regard to sex detectors, magnetic egg testers, magnetic water finders, and other devices calculated to prey upon the credulity of those who are susceptible to scientific hokum, we can only mention them. They, like the oscilloclast and the vitamin concentrates, are nothing but the old medicine doctor's stuff translated into high-brow terms.

FOUR FACTS have been definitely established where heat is converted into mechanical power. First, a reversible cycle always gives the highest efficiency. Second, the amount of work derived from each heat unit increases as the interval between the temperature at which heat is received and the temperature at which heat is rejected is widened. Third, if the heat is to be used at its greatest efficiency the heat of reception should occur only at the maximum temperature and rejection should occur only at the minimum temperature. Fourth, no heat should be allowed to pass from a higher temperature to a lower temperature except in doing work through expansion of the working fluid.

It Was Light at the Golden Gate

WHERE THE NATIONAL ELECTRIC LIGHT ASSOCIATION HELD ITS 40TH CONVENTION JUNE 16 TO 19. PUBLIC POLICY, RATES, IMPROVEMENT AND SIMPLIFICATION OF EQUIPMENT, BETTER OPERATION AND INCREASING LOAD FACTOR, LATEST DEVELOPMENTS IN APPARATUS AND OPERATION WERE SOME OF THE TOPICS COVERED

LIGHT ON every subject seemed to be the motto of the convention and Service with a Smile was certainly that of the San Franciscans who acted as hosts. Better setting of sunny weather, beautiful surroundings, an interesting city and ample quarters for meetings cannot well be imagined. From Bruce Barton's talk on How Long Should a Wife Live to Secretary Hoover's masterly discussion of State vs. Federal Regulation, the whole range of power utilization, generation and distribution was well covered in a plentitude of interesting sessions.

FIG. 1. MUNICIPAL AUDITORIUM, SAN FRANCISCO, WHERE N. E. L. A. HELD BUSINESS SESSIONS AND SOCIAL FUNCTIONS

Perhaps the most frequently stressed point was the desirability of getting to the public the message of the service that public utilities are rendering and of gaining the confidence of customers by economical supply of power and light and by giving courteous attention to their requests and complaints. The need of this was stated to be not only that business may be increased but that a well-informed and sympathetic public may be safeguarded against accepting dangerous communistic propaganda on government ownership.

In his opening address on Tuesday, President Franklin T. Griffith spoke of the requirement to raise $2000 a minute of new capital every minute for the next 10 yr. if the demands for electric service are to be met. Seven billion dollars are now invested in the industry and this is being increased at the rate of $1,000,000,000 a year, a considerable part being furnished by customers and employes, some 3,000,000 investors now owning light and power securities. It is the fastest growing industry in the world, hence has become a target for those who are bent on destroying present social and economic conditions.

Utilities now serve 65 to 70 million of our people, over half the population, this service being continually improved and extended. With a probable gross income of a billion and a half dollars for this year, the industry returns about 10 per cent in taxes to the public treasury. Government ownership would mean the substiution of tax-exempt securities for this great tax-yielding property, with not only the requirement of replacing this tax revenue by other taxes, but the probability of increasing the amounts to be raised by taxation to make up deficits from bad management of the utilities under government operation.

Fundamentally the object and the effort of utilities is to extend their service to all who can profitably use it and to keep the cost of such service at a minimum. The success under private enterprise has been great and with the practically universal supervision of methods, rates and financing by the utilities commissions, the interests of the public are safeguarded far better than they could be under political operation.

Economic fallacies in school text books, false ideas as to cost of power from hydraulic developments, the real function of holding companies in assisting financing of developments in small communities and advantages of customer ownership are some of the points to which utility men should give attention and in which public interest should be aroused.

MORE REVENUE NEEDED

It was pointed out by Managing Director M. H. Aylesworth that the Association has been operating under a deficit which has been made up by some few member companies. This is an undesirable condition and a change in dues was recommended, all class A members to pay in proportion to gross revenue from sale of light and power, the smaller ones on a basis of 50 cents per $1000 of revenue with minimum of $10, those having over $50,000 yearly revenue to pay 1/15 of one per cent of gross revenue. Holding companies, all of whose constituent companies are members of the Association, may become members with dues of $50 yearly. Practically no change is proposed for other classes of members.

BETTER HOME SERVICE

Cultivation of cordial relations with the public was urged by M. S. Sloan in his report of the Public Relations Committee. There is a story to tell of universal interest covering the growth of the industry and its service, but present efforts are too spasmodic and inadequate to put it over. Every employe should be an agency to

cultivate good will and dispel misunderstanding; co-operation with educational institutions and public organizations should be fostered and speakers trained to carry the real facts regarding the work of public utilities to every part of every community. He emphasized the need for getting right information to the children in the schools and to the farmers who are wondering how they may secure electric power.

Reporting for the Commercial Section, W. R. Putnam pointed out that extension of service to a great number of homes, many with few or no electrical appliances other than lights, was lowering the load factor and a major problem is to remedy this situation by showing customers how appliances, which are mostly off-peak load, can be used to advantage. Washing machines, electric refrigerating apparatus, utility motors were some suggestions. And to fill the night valleys, electric trucks and street lighting were proposed as desirable load.

Speaking of probable technical developments, H. P. Liversidge believed that greater attention must be given to details affecting economy and reliability. During the last decade increases in size and capacity of plant equipment has been the outstanding factor, a single unit of 77,000 kw. now being under construction. It would seem that need for continuing increase will be less in the future although the total energy demand is estimated to treble during the next 10 yr. Future increase in economy is likely to come from refinement in operation and securing better load conditions rather than from increase in size of units.

Lamp Progress

Carbon lamps are decreasing in number, according to Frank W. Smith, of the Lamp Committee, but not so fast as the great advantages of the tungsten lamp warrant. With the sturdiness of the coiled filament lamp, there is little excuse for further use of carbon filaments. The 115-v. lamp is most in use, with 120-v. increasing and 110-v. following.

In lamp manufacture, adoption of bulbs of uniform contour and finish—vacuum type for the smaller sizes and gas filled for the larger—is simplifying processes and will result in lower cost. The new A19 lamp, 25-v., will replace 12 old types and similar replacement is under consideration for larger sizes, though the problem is somewhat more difficult. The new lamps will have a smooth exterior and light interior frosting so that they can be easily cleaned, yet will give a softened and diffused light. Helical coil filaments will replace the hairpin arrangement in all sizes.

Rates Should Encourage Use

Discussing rate setting, Alex. Dow advocated a rather high initial charge with low follow on for larger use. This plan is favored by most companies and farmers seem to favor a primary charge to cover all fixed costs with very low additional charge for added power used. But utilities commissions seem to favor the plan of reduced primary charge and larger rate for current used to carry more of the overhead to the large user. Mr. Dow suggested that, as a matter of policy, it might be found wise that urban districts carry some of the cost of electric service to adjoining rural districts, thus helping to solve the problem of high cost of distribution to the farmers. He called attention to the high cost of getting capital for increasing capacity and advocated that, for large users of power, the matter of rates be left to negotiation between the company and the customer rather than fixed by the commissions. The small user, who cannot well maintain his own supply, should be protected in his service and cost, but for the user who can take care of himself, the company may well be left free to charge such rate as it finds desirable, even to refusing business which does not warrant the investment of further capital to secure the required capacity.

As to improving power factor, it was felt that this is a matter of educating the consumer to his own best operating interest rather than penalizing by high rate for low power factor.

Power Plant Insurance

Reporting for the Insurance Committee, Charles B. Scott stated that during the year a reduction in the base rate had been secured from 6 cents per $100 to 5 cents, on power houses of improved construction. Also a reduction in the penalty for use of pulverized coal from 5 cents per $100 to 1 cent. In the 5 yr., 1919 to 1923, the average annual premium rate has decreased 24.9 per cent and the ratio of losses to premium rate 34.2 per cent.

FIG. 2. SECRETARY HERBERT HOOVER ADDRESSED THE CONVENTION ON STATE VS. FEDERAL REGULATION

Mr. Scott called attention to the desirability of excluding foundations, underground wiring and piping and stacks from the co-insurance provision, since these are usually uninjured by fire. Also that the policy should cover lightning damage and fire loss from electrical disturbances, if that loss exceeds $100.

For employes' liability insurance, the rate has been reduced from $4.05 per $100 of payroll to $2.50.

Emphasis was placed on the training of personnel for fire and accident prevention, the importance of having such training and drill kept up continually and of having this work put in charge of one person who is held responsible for results.

Electric Service to Women

Use of electricity in the home and what this means to women in reducing the drudgery of housework was outlined by Mrs. John D. Sherman and further dealt with by Bruce Barton. Speaking on How Long Should a Wife Live, he showed that in the early days of the country the wives died young. Of the class of 1671 at Harvard,

10 men married, 4 of them twice and 2 of them three times, i. e., 18 wives to 10 husbands. Things have advanced but millions of women are still washing, sweeping and doing other heavy household labor which can be better done by electrical appliances at a cost of 3 cents an hour. He made a strong plea for release of mothers from this drudgery, so that they may have time and strength to devote to training of their children, which is their most important work, may live to a good old age and may keep their health and beauty to the end.

Regulation of Utilities

Several speakers discussed this live question at various sessions during the convention. The first to take it up was W. D. B. Ainey, President of the National Assn. of Ry. and Utilities Commissioners. After outlining the great growth of uilities service and the ensuing problems, he expressed the opinion that because of the divergence of conditions in different parts of the country, "It seems obvious that for the public welfare a state commission,

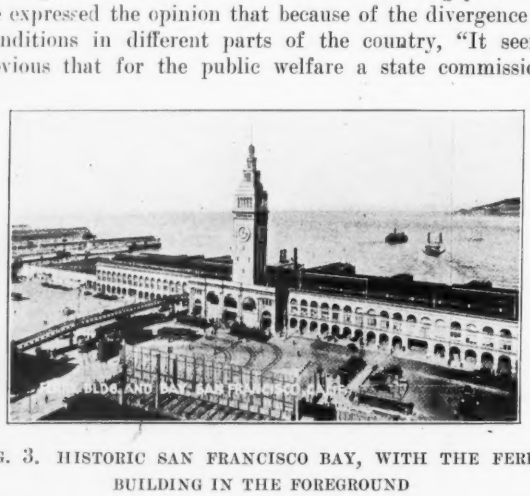


FIG. 3. HISTORIC SAN FRANCISCO BAY, WITH THE FERRY BUILDING IN THE FOREGROUND

composed of men familiar with local conditions is better qualified to speak concerning them than a Washington commission drawn from the country at large, in which perhaps but one may be familiar."

Referring to the tendency to make new laws in every contingency, he said, "We have ignored in part the truth that it is not so much by legislation, but by an enlightened and fair-minded course of conduct that the problems of living are solved. We have heard so much about mass rights that we have, to a large extent, lost sight of individual rights and are losing more and more of the latter without beneficial gain from the former."

He stated that most of living is individual, voting, paying taxes, worship, training of children, working. We are entitled as individuals to receive reasonable and proper service from public utilities, but the American people are turning away from overcentralized authority in Washington, where federal bureaus of necessity reach mass conclusions, to more intimate and individualistic control of state commissions, but "unless the public, the utility companies and the state commissions support the more intimate policies, some other answer will be found, of much less advantage to the public—lodgment of nearly all regulatory authority in some agency sitting in Washington."

Along this same line, Secretary Herbert Hoover, whose speech will be abstracted at some length elsewhere, expressed the opinion that state laws are sufficient to protect the interests of the public and that prices for electric current and returns on capital invested in the industry seem to demonstrate that the state commissions are doing their job well. "Nothing will produce worse service than to attempt to transfer local problems to absentee solution at Washington."

Hydro-Electric Progress

Regarding water power development, W. E. Creed detailed a reliability survey partially completed which showed that, for 21 units in 12 plants, the average outage was 2.3 per cent and average availability when service was required 99.7 per cent. Outage covers out of service time for trouble (which one man suggested be called "bustage"), maintenance, cleaning and inspection. Often the last three were possible during times when service was not required, which accounts for the high availability percentage. These figures compare with 12.9 per cent outage and 92.3 per cent availability for 87 steam units as given in the Prime Movers Committee report for 1923.

Forecasts of water supply are needed for effective operation of hydraulic plants. Reports of precipitation, to permit control of floods and maximum use of available power can be made from observations well distributed over large parts of the drainage area and the method is fairly well worked out and utilized. Survey of snow conditions is rather experimental as yet, but has shown good promise. Knowledge of the depth and water content of the snow blanket over the drainage area in late winter gives a means of estimating the run-off during the spring and the amount of coal which must be bought and stored for auxiliary steam plants.

Electric Service For Farms

On this subject, there was much time spent because of the great number of customers to be reached, their need for such service and the financial problems involved.

G. C. Neff, in reporting for the Rural Service Committee, brought out that agriculture uses more power, 50,000,000 hp., than any other industry except transportation. Of the 49,180,000 hp. used, 21,660,000 hp. is animals, 4,000,000 hp. gas tractors, 2,500,000 hp. steam tractors, 7,120,000 hp. trucks, 6,820,000 hp. small stationary engines, 8,000,000 hp. belted, 900,000 hp. individual electric plants, 680,000 hp. small central stations, 500,000 hp. large central stations. While the cost of this power is $3,000,000,000 a year, its use increases the farm products three fold over hand methods. Nearly half the power used is for plowing, the power for this, for cultivation and harvesting, running from 19 hp.-hr. per acre a year for corn and small grain up to 70 hp.-hr. for beets and fruit, the amount depending on the crop, the land and methods of farming. As between mechanical and animal power, the average cost per horsepower-hour for horses was stated to be 23 cents and for tractors 12 cents.

Along the same line, L. J. Taber, Master of the National Grange, said that "The farmer is likely to complain little of the cost of current, but much about the cost of equipment to make the current of service to him." He is not entitled to any special favors, only to a square deal, but the situation requires better understanding of the problems involved, among the power interests, manufacturers of equipment and the farmers. The great obstacle to use of electric current by the 6,000,000 farms not now served is that they cannot afford it under present conditions.

Mr. Taber estimated a cost of $1000 for supply installation, $500 for a water system and $300 for plumb-

ing and equipment for household and dairy and that 2,000,000 farm homes are awaiting these improvements as soon as their buying power permits. Rates must return a reasonable profit, but profits should be considered on the operation of a line as a whole, not on each individual unit. It should be an object to avoid centralization of land ownership and the small owner should have conditions made as easy and attractive as possible.

Reporting on the Relation of Electricity to Agriculture, E. A. White showed that progress was being made in all parts of the country by joint committees who were studying the problem of rural electric service. At present 25 per cent of the farms are within reach of power lines. At one mile of distribution line for three farms, costing $1000 a mile, it will take $500,000,000 to reach less than one-fourth of our farms and the farmer will need to spend $2 for every $1 of distribution line cost. This means a total of $1,500,000,000, four times the money spent on the Panama Canal, which gives some idea of the magnitude of the problem. The question is, Will it pay?

It will take time to find the answer and determine what electricity can do in increased comfort and product to warrant the expenditure and what plans will give best economy. Summary of the status of electricity in agriculture was made by Secretary of Agriculture W. M. Jardine.

Application of power has raised the amount of land cared for per worker from 12 acres in 1850 to 35 acres in 1924, with the work day considerably shortened. Use of primary power practically doubled from 1920 to 1924, while the area in crops increased only 50 per cent, the increase in power being nearly all in mechanical lines, from less than 2,000,000 in 1890 up to 28,000,000 in 1924.

Progress in generating and using power is shown by the development by the light and power companies of the United States of more electricity than that of all other nations combined. Also by reduction of cost to the consumer of electricity, in spite of rise in other costs, and by improvement in methods so that fourteen times as much light is furnished today as the customer got 20 yr. ago for the same money. And, although the annual energy production has increased 10,000,000,000 kw.-hr. in less than 5 yr., the industry uses less coal a year than at the beginning of that 5-yr. period.

Difficulty in applying power to farming comes because of the seasonal activity and because most of the operations cannot be centralized. This results in seasonal load peaks, low load factor and high cost per unit of power used. Most of the cost to the rural user is for delivery rather than for generation, because of the long lines required, the comparatively small blocks of power used and the low density of population. This means high capital investment per kw-hr. delivered and, as the consumers per mile cannot well be increased, the only solution in cutting this overhead per unit of power is to increase the amount used per consumer. This has been hindered by the high cost of current as compared to other forms of power. The solution seems to be in more economical transmission, rates adjusted to encourage larger use of current and machinery designed to do farm work faster and more economically than it has been done heretofore. Research is particularly needed in application of electrical power to field operations, which take about half the power used on the farm. The farm offers the greatest opportunities open to the electrical industry and research to solve these problems is well warranted.

Railroad Electrification

Next to agriculture, railroads offer the greatest opportunity for development of new load. Much has been accomplished in special instances of high density traffic, congested terminals and steep grades, but there are vast possibilities not yet touched. The railroads, as a whole, are our largest undertaking and largest power and fuel users. And the service required per inhabitant has increased and continues to increase much faster than population.

Limitations in size of fire box and boiler and in fuel efficiency indicate that electric service must be increased to meet the increasing demands for economical transportation, and this will be facilitated by the development of interconnection of electric systems and standardization and simplification of electrical equipment.

FIG. 4. SAN FRANCISCO CITY HALL, A SPLENDID BUILDING IN A BEAUTIFUL SETTING, INTERESTED THE N. E. L. A. MEMBERS

These points were made by Paul S. Clapp, of the U. S. Department of Commerce, and were amplified in detail by W. S. Murray, who spoke on Servicing the Railroads. He called the steam locomotive a "poor tool" which could not handle train weights and accelerations, nor give the cleanliness required in congested areas today. The reason electricity is not more used is the difficulty in financing electrification, for the railroads have needed all the money they could raise for rolling stock and track facilities.

Cost per unit of motive power, taking in locomotives and power distribution system, runs two to two and a half times as high for electric locomotives as for steam. So, in spite of the economic advantages and better operation with electricity, railroad officials have had to save investment dollars at the cost of operation dollars.

Electric utilities should join in the solution of this problem and some plan should be evolved whereby, in the cooperative action, railroad rights of way should be available for location of transformer substations and transmission lines which will serve not only the railroads but the industries and farms along the way.

Emphasis was laid by many speakers on the duties of utilities to the public and the importance of cultivating public good will. Giving a square deal and keeping people informed of just how square a deal they are getting is essential, and how to do it was the subject of many

addresses presented by the women of the industry. The value of personal contact was considered even greater than that of printed publicity and here the women employes can be of great service in informing the women and children about what utilities are doing. Even a woman supervisor of company housekeeping and personnel was advocated to see that property and plants are kept in order and that those employes who came in contact with the public will by appearance and conduct inspire confidence and liking.

This is important, not only in smooth running of the daily business of the companies, but to negative the propaganda for government ownership.

On this last subject, Henry Swift Ives, speaking on The Right to Own, said that, "The protection of property rights is a vital principle of republican institutions. It is constantly under fire of demagogues and socialists who, as a skirmish toward the battle for government ownership, work for excessive general taxes, inheritance levies

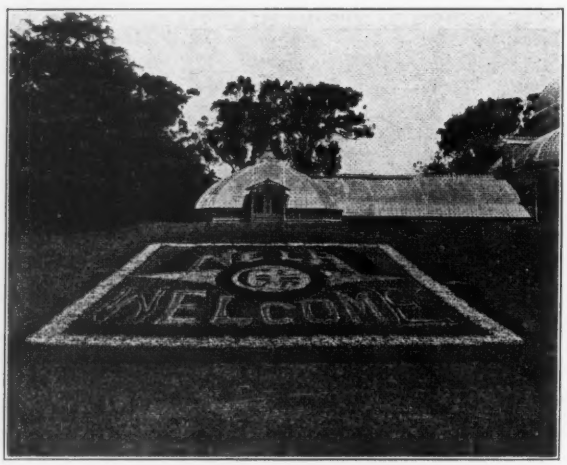


FIG. 5. THIS PANSY BED, REPRODUCING THE N. E. L. A. SYMBOL, DELIGHTED THE MEMBERS WHO VISITED GOLDEN GATE PARK

amounting almost to confiscation, limitations on income and burdensome, unfair regulations and exactions." Attack on utility properties is especially strong at present but, if such industries as light, power, gas, coal, iron, transportation—which furnish public necessities—are forced to surrender, it is well recognized that the next step will be an attack on all private property rights. These key industries are, therefore, fighting the battle for the 'right to own.'"

Co-operation and recognition of the common interest are needed. Too many property owners are ardent capitalists where their own property and business are concerned but are inclined to be socialists where the other fellow's business is concerned.

Outright opposition of all private ownership is not difficult to combat, but the socialistic lure of so-called social justice is attracting many people.

Socializing insurance by state insurance schemes is one method. Yet utilities are eager to secure capital from the big, strong private insurance companies, while utility owners and executives may be found patronizing state insurance plans. Vice-versa, too many insurance men may be found advocating state ownership of water power and city ownership of light plants and street railways. Such a situation is preposterous and should be remedied. If owners of industries can be shown the necessity of standing together and fighting openly and vigorously to protect the right to own, there will be little left of the government ownership agitation but theory.

That ownership of utilities by the people is rapidly being accomplished was brought out by B. C. Forbes, who said that customers are buying utilities securities at the rate of $1,000,000 every business day. Last year 1,900,000 new consumers were added and this year it will be over 2,000,000. Of these, some 300,000 became stock owners last year and this year over 1000 consumers are buying stock every day; a large percentage; in one company 60 per cent of these are wage earners.

As buyers of current and as owners of stock, we can serve our own interests of cheaper current and fair return on investment by using our influence for fair laws, reasonable taxes, encouraging the use of electric appliances, praising good service, objecting when utilities propose doing anything which seems unfair.

By wise action, utility companies can win enthusiastic support. For example, in 1920, 99 per cent of the newspapers were against the Alabama Power Co. and there wasn't a single stockholder in the state. By the end of 1924, 92 per cent of the newspapers were backing the company and 10,000 residents of the state had bought $12,000,000 of its securities.

Public Education

Before the Technical Section, H. Birchard Taylor, speaking of the Service of Utilities, emphasized the value of popular ownership and state regulation which John Spargo has characterized as having now proceeded so far as to make nationalization of industry seem antiquated and reactionary. Nationalization would mean an arbitrary check on the natural evolution of American economic life and a tremendous centralization of governmental power with perilous increase of bureaucracy.

Mr. Taylor advocated as a corrective measure introduction into our schools and colleges of courses in science, economics, finance and business law which might be as truly cultural as many subjects heretofore thought in academic circles to be of high cultural value. He believed that every citizen should know something about the laws of nature and their application in everyday life. That a knowledge of how and why such common devices as the telephone, electric motor, automobile and radio work would be as broadening as the conjugations of Latin verbs, exact dates of ancient history or the exports of Para. And that men trained in a knowledge of these things from the lowest school grades would develop a more logical viewpoint and greater power of logical analysis, which would make them less susceptible to fallacious argument as to unsound investments and projects, while enabling them to get more out of life by a better appreciation of what is going on around them.

Mr. Taylor advocated also the broad view in engineering which recognizes the value of individual knowledge and attainment and is willing to spend money to encourage engineering progress rather than awarding contracts on a basis of price alone, which would reduce station construction to a matter of cheapness rather than performance.

More and Better Load

Under this general head came most of the subjects taken up by the Commercial Section. Pushing of electric household appliances was especially advocated, as it means increased revenue with no increased investment for plant or distribution system. Investigation has shown that a family having no appliances uses an average of 4 kw-hr. a month, while the use with only a few appliances will increase to 40 kw-hr. and a well fitted home with iron, washer, vacuum cleaner, sewing machine, fans, refrigerating machine, range and heater is estimated to use as high as 230 kw-hr. a month. This will be largely off-peak on the daily load curve and the hot-weather appliances will tend to fill the summer valley.

In Cincinnati, a campaign to increase appliances resulted in an added revenue of $1,000,000 a year.

The report included complete selling plans for cleaners, washing machines, utility motors and irons.

Report on cooking and heating showed from tests that the range peak depends on the season, coming earlier in winter than in summer, that this peak demand is from 0.87 kw. per range for apartments to 1.75 kw. per range for large houses, and that the average consumption runs from 3 to 4.5 kw-hr. a day per range. Records show the cost of servicing a range to be $0.34 a call, the repair parts costing $0.258, billed to the customer and the service $0.084, which was given free. The best plan was considered to be to bill service calls at net cost of parts and labor.

Cost of wiring for a range ran from $30 to $125, with an average of $61 for conduit construction; $25 to $75, average $46 for BX wiring; $30 for open wiring.

Heaters are mostly used where ranges are installed. Reports from 9 California companies showed 7183 metered heaters, mostly 4 or 5 kw. rating; of these 87 per cent are of circulation type and 58 per cent have thermostatic control. Those which give continuous service use an average of 574 kw-hr. a month, while the intermittent type average 210 kw-hr. a month, mostly operating on the heating and cooking rate schedule at about 2 cents a kilowatt-hour.

Electrical refrigeration is another important and increasing assistance in improving load factor. Details of several makes of machines are given in the report and data from tests of refrigerators serviced with ice and electrically. It also gives the principles of the various systems used.

Because of the rather high cost of the outfits, they must be sold by canvass and carefully serviced. First cost depends on the make and size of machine, so cannot be averaged. But in Minneapolis the installation cost was found to be $28.50 per machine and cost of servicing $13.86 a year. In Baltimore, the cost of servicing was $0.12 to $7.57 a year, depending on age of the machine, and average calls required were from 1.5 to 4.42 per outfit. Cost of servicing in Chicago was found to be $16.92 a year per outfit, a cost of $1.34 a call. The chief reasons for service calls were: thermostatic trouble, 29 per cent; motor trouble, 12 per cent; valve trouble, 10 per cent; belt trouble, 9 per cent; idler pulley, 5.5 per cent; compressor, 3.5 per cent; miscellaneous, 16.5 per cent; useless calls, 14.5 per cent.

On Merchandising Electrical Appliances, Edward N. Hurley stated that improvement in transportation was helping keep inventories to a minimum, as prompt deliveries permitted carrying 20 per cent less stock than was needed 5 yr. ago. But demand for peak load service forces light and power companies to invest 40 per cent of its capital in capacity which is idle during off-peak hours. If appliances could be put into use so as to increase the present revenue—$266,000,000—from appliance load, by 20 per cent, it would mean added annual revenue of $54,000,000 or 6 per cent return on the now idle equipment.

At present, only 49 per cent of central stations are merchandising appliances. If the rest started an active campaign, there should be no difficulty in getting the added 20 per cent of revenue. Co-operation to increase sales of local dealers will also help greatly in adding appliances to the connected load. Most of such appliances come into the specialty class and require sales service, demonstration and some service after installation. The "shopping store," handling many parallel specialties of different makes will not do as well, since it creates confusion and doubt in the mind of the buyer.

Service is important in securing satisfaction of the user and increased sales. When the purchase is from a public service company or electrical dealer, the buyer feels that he will be taken care of when service is needed, which is an advantage to all concerned. But central stations should insist on thorough mechanical and electrical tests of appliances before recommending to customers and insist on high standards of performance.

Station Apparatus and Operation

In ventilation of generators, it is found that an inert gas gives considerable reduction of temperature over air and that a 20 per cent carbon dioxide mixture is apparently successful as a means for extinguishing fires and, as only ¾ of the volume of air is required for equal cooling, the power for circulation is only 2/3 that for air. Hydrogen has high thermal conductivity, hence needs but low temperature difference to carry heat from the machine to the cooler. It causes no insulation damage from corona effect, creates no fire danger, if air is excluded from the system, and permits carrying 30 per cent greater load with 1 per cent better generator efficiency.

Field temperature of a.c. generators is measured by the rise in resistance and a temperature alarm is placed in the cooling medium current. Piping complication to used condensate for cooling generator air has been found too great to warrant such use except where clean, fresh water is scarce. Salt water has been used in 1-in. tubes to some extent, but fresh water in smaller tubes is preferable.

Rating Equipment

Motor ratings have not come to a settled basis, but efforts have been made to get a basis which will avoid using over capacity, as it is found that customers' motors are largely running at 60 per cent capacity or less, resulting in low efficiency and power factor. Proposal is to rate for capacity at 40 deg. C. rise above 40 deg. C. temperature of ambient air with a secondary rating indicated for 25 deg. C. air temperature.

Study is needed and is under way for transformer voltage and ratio ratings and for strength under short circuit conditions.

Losses from low power factor and their prevention are being studied, also schemes for system connections and the relation of component parts of a system, load

despatching, operating routine and methods of switching and communication.

Because of wide variation of requirements, it has not been found wise to try to prepare standard specifications for equipment, but a guide to specification writing has been formulated showing the points which need attention and how to draw up provisions which will secure the desired results.

Grounding of neutrals through resistors calls for protection of the resistors against overload and the tendency is to use a time or temperature relay or to ground solid without a resistor.

Substations and Interconnection

In substation practice, increase in load calls for heavier switching apparatus, which means remodeling, replacing or using reactors to limit the current. Some break switches are made non-automatic and backed by group automatics to cut down cost and complication. In discussion it was pointed out by P. B. Junke that sectionalizing a system effected a reduction in obsolescence on the older switch gear, as it reduced the currents to be handled in emergency breaking.

Alex. Dow advocated the loose coupling of interconnecting stations and systems, letting each station handle its own load normally and interconnecting only at natural points as circumstances require. Then use the best switch that can be procured, of capacity to handle the maximum load that it can be desired to interchange and uncouple in case of serious fault so as to isolate the affected area. He said that location of stations and interconnected transmission lines must be made on a guess as to future development, often with disregard to best economic engineering consideration of the present conditions. Engineering and executive departments need to understand each other's problems better and should have a liason officer to bring it about.

Motors for Pulverized Fuel

For pulverized fuel plants, if d.c. motors are used, they should be enclosed. For a.c. motors both open and closed types have their advocates but, if open are used, they should be blown out frequently and taken down for overhauling once or twice a year. Large air gap is better than small, as it is less likely to cause an accidental rubbing spark or heating, and bearings should be tight so that no oil can get into windings, as this mixes with the fuel dust and clogs the ventilating ducts. Controllers must be kept free from dust by being placed in a separate room which is kept under slight air pressure or by putting air pressure into the controller case through a pipe.

Street Lighting

Series lighting is growing in favor, using pole type regulating transformers and standard distributing circuits. Fewer substations at longer spacing reduces station cost, but increases feeder cost and the plan should be such as to reduce the combined cost to a minimum. For loads of 1000 to 15,000 kv.a. per sq. mi. the arrangement will usually be a substation for 1 to 4 sq. mi., which gives spacing of 1 to 2 mi., according to load density. This is for e.m.f. of 4000 to 5000 v.

The trend is towards automatic substations with automatic circuit breakers, load shifting and reclosing. Most of the trouble found is from bellows type relays and a.c. solenoids, the latter now being replaced by motors. Remote control and indications are generally satisfactory, but some trouble has been experienced from leakage, grounds and lightning, so that systematic maintenance is required.

Overhead Transmission

Transformers and switch gear above 15,000 v. are now usually installed outdoors. Such installation may be used down to 2300 v., but there is no material saving. Oil circuit breakers and disconnects are interlocked so that the latter cannot be opened with the breaker closed. The interlock may be operated by key, electric or mechanical control.

Switching by units rather than by single pieces of apparatus simplifies switch provision, the transformer break being generally made on the low-tension side. Air break is not considered feasible except at light loads. Difficulties with outdoor air breaking are usually from poor contact, lost motion, rusted joints, breakage, wear, loose insulators or lack of lubrication. Fast or slow breaking depends on circumstances. For single break, operated by hand, it is better to open slowly and, if an arc persists, to close again. For gang operated switches, it is better to open quickly.

For overhead line construction, a handbook is in preparation, as reported by Mr. Gow. In some phenomena there is need for further study. Conductors are found to vibrate vertically at times, the amplitude being as great as 1 in. and frequency 13 to 30 cycles per second. The vibration seems to be independent of temperature, load or energy conditions and is believed due to slight air currents. In one case a stranded ground wire was found broken, 4 strands apparently by vibration and the remaining 3 strands by over tension.

For suspension insulators it is found that high tensile strength is needed and tests were made of 5 high-strength makes under mechanical and electrical strain. At 9000 v. all were in good shape; at 11,000 v. one specimen failed electrically; at 13,000 v. two makes failed electrically; at 15,000 v. one make was intact electrically and mechanically, one was all right mechanically but failed electrically, the other three were not in so good condition. Further tests showed that the electric puncture leaves a defect which later is the starting point of mechanical failure. All insulators will apparently hold half their ultimate strength indefinitely so that a load of 1/3 the ultimate srength seems safe.

Surging, from klydonograph photo records on the 220,000-v. Big Creek Line, is chiefly of small value and small extent. Most of those 1.5 times normal and over were due to switching. Maximum values were 2.17 to 3.25 times normal voltage and did not travel far from the station where switching was being done. Of two flashovers observed, there was no abnormal surge accompanying nor sufficient e.m.f. to cause the flashover.

Underground Construction

For underground lines cable construction is the chief problem. Cable failures are found to increase as the temperature range increases and are believed to be due, in many cases, to dirt in the cables. Possibly, for very high tensions the single conductor cable will be the ultimate design. It is felt that joint failures in cable systems are much more frequent than they should be and that high cost of joints is warranted, if it will cut down the

number. Cable manufacture is improving and in foreign countries joint costs as high as $300 have been recorded.

Carelessness in pulling in cable is sometimes found, also motion of cables in conduit after installation is found to cause trouble at duct ends. A method of support at duct ends was explained by Mr. Rohrbach, as used by him at Spokane, Wash., which has reduced the trouble at this point materially.

Prime Movers

Changes in prime-mover practice have been reported during the year in a series of bulletins and have already been presented to Power Plant Engineering readers. The present report gave the Piron process for distillation of coal at the Ford plants as being in a state of change to remedy defects and the plant of the Combustion Utilities Corp. at Washington, Pa., as operating but with no details yet available. European optimism of a few years ago on the low-temperature carbonization of coal has been proved too great, as no great amount of gasoline is secured and the low temperature tars are salable only as a substitute for heavy fuel oil. The industry can only be described as in a state of experimental development.

Revision of fuel specifications is under way but the report is deferred for further consideration and the feasibility of off season purchase and storage is also being carefully canvassed.

Specifications for piping, especially for high pressures are tentative, while waiting for suggestions of change from station men and pipe manufacturers. Reports indicate that no troubles have been met which could be laid to high pressures. Effect of high temperatures on the properties of materials is being investigated and a report on operating experience, also code for high-pressure piping is expected next year.

Tendency is more and more toward installing much equipment in open air and studies are under way on the elimination or reduction of buildings for housing power stations.

In steam units, it is found that high pressure and temperature does not impair reliability in units up to 40,000 kw. That reheat between stages can be used—put on or taken off—with no change in the adjustments, is demonstrated with the 60,000-kw. units at Crawford Ave. station in Chicago.

At the Boston Edison Co. the equipment for 1200-lb. pressure will soon be ready for trial.

A 77,000-kw. unit is now being constructed and the question again arises, What will be the limit of size? Opinion was expressed that so long as a bigger unit can be handled as easily as a smaller, there will be gain in economy from increased size and nobody can yet predict the limit.

Report on mercury boiler progress gave troubles encountered at Hartford as chiefly from leakage in the boiler tube joints because of great temperature variation. The unit ran better at lower loads, hence, was carried there most of the 2400 hr. that the unit ran. It is now down for reconstruction and a new boiler is being developed which has separate tubes of calorized metal and all welded joints, so that it should be free from strains. Each of the six boiler sections will be replaceable and provision will be made to protect operatives from mercury fumes in case leaks do occur. Also a 3-stage turbine is being developed to replace the 1-stage of the former plant.

It is expected that the new plant will be operating at Hartford in 3 mo., and, if it proves satisfactory, larger installations will be made.

Water Power

In his report on combined steam and hydraulic stations, Herbert A. Barre said that the start for comparison as to economy of a water power is always an all-steam station. The question then comes of economy of developing the water power and, if the economy seems about the same, of using the water to save fuel or to make it available for other uses than stationary power.

Many big water power plants have not heretofore been developed because their economy could not be shown. Those wanting power are primarily interested in getting it, not in the cost of development, but the source must be the cheapest possible to satisfy the utilities commissions. In laying out a program for development, at least 5 yr. ahead must be considered and 10 yr. ahead should be kept in view.

Figuring the cost of power from steam plants requires that variation with cost of fuel be considered and the cost of keeping a plant hot be taken into account. For instance, at Long Beach, it takes about 250 bbl. of oil a day to keep the plant hot and above this the plant yields 433 kw-hr. per barrel of fuel. Because of this condition and the variable amount of water available, it often pays to use the steam plant as a solid block of power for the base load and vary the water power according to the peak demands rather than to use the steam plant for the peaks.

Special Trips and Features

Besides daily entertainment to ladies and delegates, there were extended trips after the convention to the Big Creek development, the Pit River development and the Hetchy-Hetchy municipal plant of which many took advantage. The Electrical League of San Francisco gave a luncheon on Monday, the Commercial Club on Thursday, the Oakland Advertising Club on Tuesday, and the Electric Vehicle League on Thursday, at all of which prominent leaders addressed the gatherings. There was no lack of bodily or mental nourishment. The main social features for the entire convention were the President's reception at the Fairmont, Monday evening, and Gala Night, Thursday, at the Auditorium, at which dancing was interspersed with specialties from all the theatres of the city.

Secretary Hoover's address was the most largely attended session, hardly a seat in the vast auditorium being vacant, and those present were well repaid for attendance.

Prizes Awarded

Awards of prizes were made to the Consumers Power Co. of Michigan of the Charles A. Coffin Medal for distinguished contribution to the development of the light and power industry during 1924. This company increased its consumers 11 per cent, its supply to residences 21 per cent and to commercial customers over 17 per cent. Eighty-seven per cent of the homes in its territory are now served with electricity. Accidents were decreased over 1923 and hours lost due to accidents by 48.3 per cent. During the year, the company built 244 mi. of transmission, of which 123 mi. carry 140,000 v.; it increased distribution 13.5 per cent and built five new 140,000-v. substations. Employe stockholders increased 23 per cent and customer investors 55 per cent, the expenditure for better service being $12,700,000.

For review and forecast of the electric light and power industry 1920 to 1930, Bonbright & Co. of New York offered $10,000 in prizes and another prize of $10,000 was offered by the board of directors of the American Superpower Co. to be awarded in 1930 to the contestant whose forecast, reviewed at that time, shall appear to have most nearly approximated the facts. Some 438 papers were received and prizes were awarded as follows:

First prize, $5000, to David Cowan of Montreal, a young man 22 yr. of age, in the investment department of the Sun Life Assurance Co. Second prize, $1000, to Robert M. Davis, of the Electrical World, New York. Third prize, $500, to John Dockendorf, of the Milwaukee Elec. Ry. & Lt. Co. Ten prizes, $250 each, to Reuben B. Slight, Minneapolis; Arthur R. Stubbs and Chas. H. Churchill, Jr., of Schenectady; C. E. Neil and Chas. Donaldson, of New York; M. L. Sindeband and P. Spron, of New York; A. K. Baylor, of New York; C. P. Dunn, of Portland, Ore.; C. T. Chenery, of New York; Theodore Dwight and Reginald Frankchold, of New York; David Evans, of Montclair, N. J.; M. J. Verderey, Jr., and H. A. Moe, of New York. Ten prizes of $100 each to F. E. Pierce and R. T. Dana, of New York; Merrill E. Skinner, of Pittsburgh; Paul A. Ryan, of Susquehanna, Pa., Pearson Winslow, of New York; Louis R. Davis, of Chicago; Chester M. Clark, of Boston; Edgar A. Van Dusen, of Poughkeepsie, N. Y.; Prof. T. H. Dillon, of Harvard University; Theodore H. Brown, of Stamford, Conn.; Frank H. Simmons, of Woonsocket, R. I.

The first three prize winning papers will be published by Bonbright & Co., also an analysis of the six leading papers.

New Officers

In accordance with usual custom, the first vice-chairmen of sections were advanced to the chairmanship. For the Technical Section, C. F. Hirshfeld; for the Public Relations Section, H. C. Abell; for the Accounting Section, Walter C. Lang; for the Commercial Section, F. D. Pembleton.

Officers of the general association elected were:

President, J. E. Davidson, of Omaha; Vice-Presidents, R. F. Pack, of Minneapolis, H. T. Sands, of Boston, P. S. Arkwright, of Atlanta, and John B. Miller, of Los Angeles; Treasurer, W. A. Jones, of New York. Executive Committee, Franklin T. Griffith, Portland, Ore., ex-officio; for 3 yr., Edwin Gruhl, of New York, E. M. Herr, of New York, H. M. Edwards, of New York; for 1 yr., Clyde Chamberlin, of San Francisco, and W. E. Robertson, of Buffalo.

Next year's meeting place was not decided, but Atlantic City is making a strong bid for it.

James B. Duke, president of the Southern Power Co., 511 Fifth Avenue, New York, and interested in other electric utilities, is at the head of a project to construct and operate a hydroelectric generating plant at Chute-A-Caron, near the Grande Descharge dam, Quebec. The Government of the Province of Quebec has granted permission for the enterprise, and preliminary work will be placed in progress in the near future. The entire development will approximate 600,000 hp., with a network of transmission lines for service throughout this section, including as well power for a proposed aluminum plant to be constructed by the same interests on neighboring site. It is purposed to establish a model industrial town for employes at the plants. The complete project is reported to involve in excess of $25,000,000.

New Water Gage Safety Valves Open Automatically

WITHIN ONE minute after the new gage glass has been replaced and the packing nuts tightened, the valves open automatically and the new glass goes into service. That is a feature which makes the Wulf automatic water gage safety valve different from other valves for this service and one which renders it doubly automatic.

Views of these valves, which are being marketed for stationary service by the Wulf Automatic Safety Valve Co., of 4124 N. Keeler Ave., Chicago, are shown in the accompanying illustrations. Figure 2 shows in detail the interior of the upper automatic valve. It consists, as will be noted,

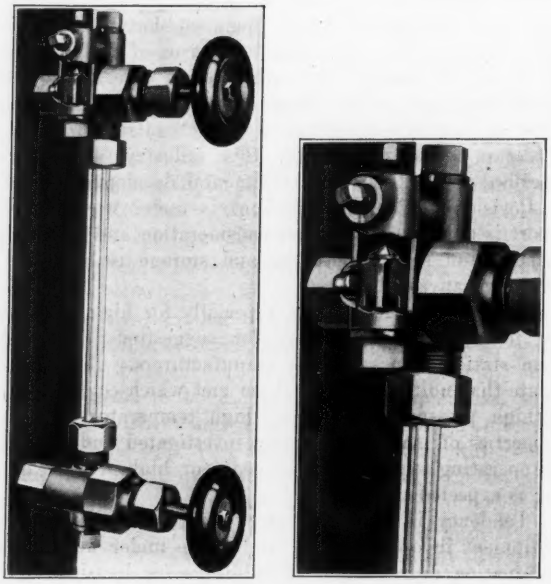


FIG. 1. ASSEMBLY OF WULF AUTOMATIC WATER GAGE SAFETY VALVES

FIG. 2. PARTIAL SECTION OF UPPER VALVE SHOWING GROOVE IN VALVE DISC FACE

of a cone shaped valve disc normally held away from its seat by the force of gravity. Across the face of this valve disc is machined a small groove, the purpose of which is to permit a small amount of steam to leak past the valve when it is closed. The bottom valve is constructed in the same manner except that the leakage groove is omitted.

In operation both steam and water hand valves must have full opening at all times and need not be touched in case the water gage glass breaks as the automatic valves will instantly shut off all steam, except that which leaks out through the groove. This, however, is so small that it in no way interferes with the replacement of the glass. As soon as the glass is in place and the packing nuts tightened, the small steam leak past the upper valve permits the pressure to build up inside the glass, thus gradually equalizing the pressure on both sides of the valves. This condition of equilibrium is usually reached within one minute after the packing nuts are tightened and the valves then drop away from the seats by virtue of their own weight. The glass is then again in service. During the time that the pressure became equalized, the steam leakage allowed the glass to warm up gradually, thus eliminating all danger from breakage due to sudden expansion strains.

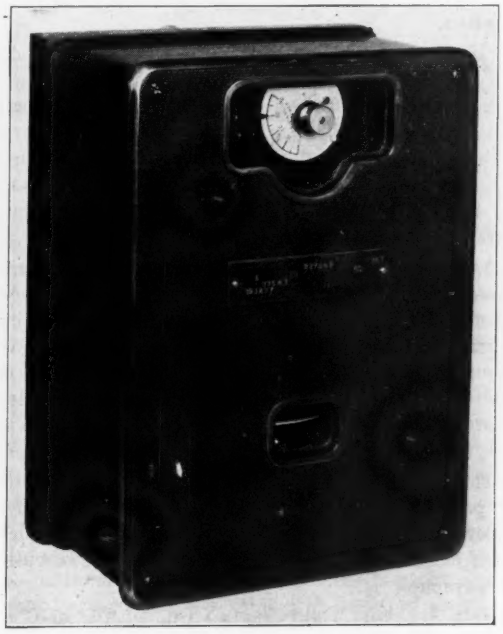
Another valuable feature of this valve is that the glass is inserted through the top, by simply removing the large screw plug at the upper part of the valve. The glass extends for some distance into the interior of the elongated chamber shown on the right and for this reason it need not be cut to an exact length, in fact, this feature permits of a variation in length of glass of approximately 2 in.

These valves have been tested out for a period of over three years on locomotive service with excellent satisfaction. They are made of bronze and may be had in a large variety of sizes, and are tested for modern boiler pressures.

All parts of the valve are readily accessible for cleaning, which may be done under a full head of steam, if necessary, by simply closing the hand valves.

New Relay for Use on Distribution Lines

EASE OF calibration is one of several valuable features incorporated in a new power limiting relay recently developed and placed on the market by the General Electric Co. of Schenectady, N. Y. This relay is for use in limiting



NEW GENERAL ELECTRIC TYPE IG-103 POWER RELAY

the power on distribution lines to a predetermined quantity. It has a large range of calibration, running from zero to 1000 w., secondary, heavy contacts are used, and the internal mechanism is simple. It can be calibrated without removing the cover by means of a knob projecting through the glass window at the upper part of the case. A view of the device is shown in the accompanying illustration.

This relay is manufactured in three forms; the IG-102, an "over power" and "under power" device with contacts for controlling either alternating or direct current, and two "over power" devices, one for alternating current and the other for direct current, known as the IG-103 and IG-104, respectively. By rotating the knob at the window, the relay may be adjusted for operation at any deviation from the desired load. A graduated dial, mounted beneath a fixed needle, rotates with the calibrating knob, giving visible indication of the load setting.

Merger of Southern and Western Utilities

PLANS HAVE been consummated for a merger of 10 large electric light and power utilities in Arkansas, Texas, Idaho and other states, providing for a complete interchange of operating facilities to furnish commercial service to more than 350 communities. The companies included in the consolidation are the Arkansas Light & Power Co., Pine Bluff; Louisiana Power Co. and Louisiana Power & Light Co.; New Orleans Public Service Co., New Orleans; the Pine Bluff Co.; Mississippi Power & Light Co., Jackson; Dallas Power & Light Co. and Dallas Railway Co., Dallas, Texas; Texas Interurban Railway; Idaho Power & Light Co., Boise; Nevada Power Co., Jarbridge; Utah Power & Light Co. and the Utah Light & Traction Co., Salt Lake City. The aggregate value of the properties included in the merger is estimated at $250,000,000, comprising steam-operated and hydroelectric generating stations, substations, transmission lines with franchises, and distributing system. The various companies will continue to function as individual units and plans are under way for connection of different transmission systems to form a complete network. Other expansion is also under consideration, including extensions in generating plants. The merger will be carried out by means of a holding company, of which Harvey C. Couch will be president. Mr. Couch also heads the Southern Power & Light Co., heretofore controlling units at Pine Bluff and vicinity, now included in the consolidation.

News Notes

STANDARD POWER & LIGHT CORP. of Delaware, has completed arrangements to acquire by purchase, a majority of the voting shares—represented in part by voting trust certificates—of Pittsburgh Utilities Corp., which controls the utilities supplying electric power and light, gas, street railway and other services in the City of Pittsburgh, Pa., and its adjacent territory, and other large properties in connection. The properties have combined gross earnings in excess of $58,000,000 annually.

Ladenburg, Thalmann & Co. and H. M. Byllesby & Co. will jointly control Standard Power & Light Corp. United Railways Investment Co., which owns nearly all of the remaining voting shares of Pittsburgh Utilities Corp., will be jointly controlled by Ladenburg, Thalmann & Co. and H. M. Byllesby & Co. The latter have acted in this matter also for Standard Gas & Electric Co., which will have a substantial investment in both situations.

GEORGE J. HAGAN Co., Chamber of Commerce Building, Pittsburgh, Pa., has recently taken over the sales, service and manufacture of the Hagan steam jet ash conveyor which was known as the Hagan Detrick ash conveyor and was formerly handled by the M. H. Detrick Co., of Chicago.

DEAN HILL PUMP Co. announces the appointment of Wagner & Wagner, El Paso, Texas, as its local dealer in the El Paso territory. Also J. Harry Burroughs, Marine Trade Building, Buffalo, N. Y., as local representative in the Buffalo district.

THE MANCHESTER TRACTION, LIGHT & POWER Co. of Manchester, N. H., has had plans prepared for the construction of an addition to its power plant at Kelley's Falls which will cost approximately $300,000.

THE NATIONAL ELECTRIC POWER COMPANY, which owns practically the entire stock of the Cumberland County Power & Light Company of Maine and the entire common stock of the Northwestern Public Service Company, of Nebraska and South Dakota, has just issued 7 per cent cumulative preferred stock to the amount of $1,500,000.

THE NARRAGANSETT ELECTRIC LIGHT COMPANY, Providence, R. I., have prepared plans for a switchhouse extension, to be four stories high, of brick and cast stone, 28 by 25 ft.

THE FALL RIVER ELECTRIC LIGHT CO. of Fall River, Mass., has been granted permission to issue $2,000,000 worth of 20-yr. 5 per cent bonds. These are to be used in retiring indebtedness of $1,210,000 and to pay obligations incurred in the purchase of stock of the Montaup Electric Company.

IDEAL COMMUTATOR DRESSER CO., Sycamore, Ill., has opened a branch office in the Fulton Bldg., Pittsburgh, Pa., where a stock of its products will be carried for emergency purposes. R. F. Waldo, for a great many years connected with the New York office, has been appointed district sales engineer.

THE MAINE LEGISLATURE HAS PASSED the bill granting permission to Dexter P. Cooper and others the right to issue bonds with the consent of the Maine Public Utilities department, to generate power from the tides of the Bay of Fundy, which touches Maine along its northeast border, and to export such power beyond the limits of the state. The bill, however, makes it unlawful to export power made in any other manner than by tide water beyond the borders of the state. Until the passage of this bill it has been illegal to export power manufactured by any means beyond the borders of the state.

Books and Catalogs

SUPERHEAT ENGINEERING DATA—A Handbook on the Generation and Use of Superheated Steam. Sixth Edition Revised. The Superheater Co., New York, 1925. Bound in Keratol, 4½ by 7 in., 208 pages, 85 illustrations and diagrams, 69 tables. Price $1.

This handbook contains condensed data for steam power plant engineers and operators, with an index consisting of 16 pages, assuring ready reference. Superheated steam, its advantages over saturated steam, and the proper design and performance of superheaters, are briefly discussed. It illustrates superheater arrangements in practically all stationary, marine and locomotive type boilers commonly made in America. Waste heat, portable and separately-fired superheaters are also shown. Brief comparative data are given as to sizes, tube sizes, arrangement of tubes, etc., for the stationary water-tube boilers illustrated. The steam tables cover pressures from below atmospheric to 600 lb., absolute, and include properties of superheated steam from 50 to 300 deg. F. superheat.

In the section on piping is found information for figuring piping for handling water, saturated and superheated steam, and the velocity and pressure drop of water and steam flowing through piping. In this section are included also the proposed American standards for high pressures. Superheat Engineering Data also contains engineering data on coal and oil-fired boilers, with tables on heat values for gaseous, liquid and solid fuels. Other miscellaneous data are complete conversion tables, bolts and screw threads, with the recent work of the American Engineering Standards Committee, and the National Screw Thread Commission, and other tables frequently used by steam engineers.

"A HOUSE OF CHEMICAL ENGINEERS" is the title of a booklet, recently issued by the Dearborn Chemical Co., of Chicago, Ill., which describes, by means of pictures, the work, equipment, and organization of this company, which was founded in 1887, and whose work has extended through the field of steam production, from the stationary boilers of manufacturing, public utility and service plants to the railway and marine field. Water treatment, lubrication, rusting of metal products, and other problems of industries have had the benefit of Dearborn Laboratory investigation and research, and dependable products in these lines have been developed.

COKAL STOKER CORP., Chicago, Ill., has just issued a treatise upon comparatively small industrial power plants which is well illustrated with charts and curves in two colors showing exactly how furnace operation varies with boiler output, the effect of stack temperatures upon economy and the influence of soot blowing upon stack temperature, together with other technical features of power plant operation.

"MEETING THE DEMAND" is the title of an article recently published in Trade Winds and reprinted in pamphlet form by the Brown Hoisting Machinery Company of Cleveland, Ohio. This article was prepared by Alexander C. Brown, president of this company, and is a pictorial history of ore and coal handling on the Great Lakes docks. The illustrations are attractively arranged and the text matter clearly describes the views shown.

ASHTON HIGH CAPACITY pop safety valves are described in circular "C," recently issued by the Ashton Valve Co., Boston, Mass. In addition to a detailed description of the cast-iron and cast-steel pop safety valves, the circular contains a table, giving the discharge capacities for valves ranging from 2 to 4½ in. in diameter and for pressures varying from 10 to 400 lb.

"DIAMOND STEAM HOSE" is the title of a little pamphlet sent by the Diamond Rubber Co. of Akron, Ohio. Working pressures, list prices, the use of coverings and the proper method of attaching couplings, together with other points of interest to users of steam hose, are discussed in this pamphlet.

THE ILLINOIS ENGINEERING CO., of Chicago, is distributing a bulletin, describing the Eclipse steam trap. This bulletin calls attention to the special features of the trap, illustrates its action and gives a table of capacities for the various sizes manufactured.

LINK-BELT CO., of Chicago, has just issued an 8-page booklet which describes the operation and use of the Link-Belt gondola car dumper. This book contains many photographs of installations and line drawings showing method of operation.

USES AND VALUE of automatic arc welding, together with a description of the welding apparatus and generating equipment used are given in Bulletin 48937.1 entitled "Automatic Arc Welding," recently issued by the General Electric Company.

GENERAL SUPPLY CO., 521 Arch St., Philadelphia, Pa., has recently branched into the power plant supply and repair business and wishes to receive catalogs and literature of manufacturers of power plant equipment.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

In This Measure Shall They Be Free

Nearly a century and a half has passed since this nation declared for political freedom.

In this period that inherent desire for life, liberty and the pursuit of happiness has permeated more and more the social and economic structure of the country.

At the time of the Declaration of Independence, incidence of birth largely controlled the destinies of men.

Not only were people "born to the purple" of the governing classes but also, in every other walk of life, sons were expected to follow in the footsteps of their fathers regardless of natural aptitude or changing economic conditions.

Institutions of all kinds were tied down to tradition and caste similar to that in autocratic government, so that religion, science, the arts and trade were dependent on the patronage of the governing classes.

Such a social order appears to Americans of today so abhorrent that the right to determine who shall make and enforce our laws is perhaps the least important of the new order of things which is the outgrowth of that early spirit of independence.

Fanned by the sacred flame of political freedom, a like spirit of enterprise, initiative and independence extended itself to other enterprises.

Occupation has changed from craftsmanship, handed down from father to son, to free choice of whatever trade, business or means of livelihood a person may decide to enter upon.

Manufacturing, business, fraternal, religious and charitable institutions are now initiated by individual enterprise freely exercised wherever an opportunity seems to exist.

Out of the ideas of refusing to tolerate taxation without representation; of separating the state from support and control of church, art, invention and trade; of making advancement depend on service to the people instead of the favor of a person, has grown the latest and greatest movement of modern times, the increasing insistence on knowing what we pay for and why we pay it.

No longer do institutions have secret budgets or leave the inner workings of their business in the hands of a few individuals.

They try to make each stockholder and each customer familiar with how his dollar is spent and the service he receives for it.

Such a policy naturally leads to competition in furnishing more and better service and this forces the issue of analysis of every unit instrumental in that service.

For without separation into units there can be no scientific analysis, without correct analysis there can be no just judgment, and without wise judgment there can be no improvement.

In power plants we see men, methods and machines placed squarely "on their own." Each is measured and compared, discarded and improved, solely on its merits without fear of any power or favor of any person.

Motivating these progressive activities, speeding them up and keeping them in hand, is free and general discussion, the broadcasting of facts as they are found, which is developed to its highest and most economical form through the printed page.

To modern science and to progress in all art, crafts, industries and institutions, freedom of the press is as essential to life, liberty and the pursuit of happiness as freedom of speech was to our ancestors in the fight for self-government.

In the highly specialized field of publishing, represented by the Associated Business Papers, Inc., of which Power Plant Engineering is a member, there are technical and business problems to be met analogous to those arising in the field which each publication serves.

The first is the choice of objective. Like the power plant itself, this publication which serves power plants must build to serve a certain field. If it seeks to extend itself to furnishing more kinds of service than conditions favor, it may so reduce the quality or quantity of its service as to be of little value. If it becomes too highly specialized it may fail because of the incompleteness of its service.

Power Plant Engineering strives to serve the men who are in active charge of the generation of power in their professional lives alone.

Deliberately and in the face of frequent opportunities to do otherwise, Power Plant Engineering shuns all other services to its subscribers, such as those that have to do with the political, religious, fraternal, social or other sides of their lives.

Only from the desire to maintain the best possible service in its chosen field, does it restrain from giving other service.

Power Plant Engineering is selected by its readers solely for the specialized service it gives. No other reason can exist for any man to subscribe for this publication except the one reason of its helpfulness in his chosen work of planning, building and operating power plants.

Its subscribers pay for what they receive and if they fail to receive full value for their money they will soon cease to be subscribers.

Like freedom of choice is the reason that manufacturers use its pages. No affiliations or outside influences can exist for the publication of any advertisement in Power Plant Engineering except the one reason of a desire to place products squarely before its readers on their merits alone.

Needless to say that ideas, methods and products presented in these pages must be those of extraordinary serviceability to engineers of the most independent judgment.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS
Hercules Float Wks., Springfield, Mass.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR FILTERS.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Lavino & Co., E. J., Philadelphia.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyors Corp., Chicago, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH TANKS.
Conveyors Corp. of America, Chicago.
United Conveyors Corp., Chicago, Ill.

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.
Flexible Steel Lacing Co., Chicago.

BELTING.
New York Belting & P'k'g Co., New York.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J., Philadelphia
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 158

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N.Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N.Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills, McCanna Co., Chicago, Ill.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw,

BOOKS AND SCHOOLS.
Sweet's Catalogue Service, Inc., New York, N. Y.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, O.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
King Refractories Co., Inc., Buffalo.
McLeod & Henry Co., Troy, N. Y.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The Hartford, Conn.
Sherwood Mfg. Co, Buffalo,

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Fairbanks, Morse & Co., Chicago.